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Ministry of
Environment
and Parks

WATER
MANAGEMENT
BRANCH

THE pH TOLERANCE OF THE AQUATIC PLANTS OF BRITISH COLUMBIA

PART 1.

LITERATURE SURVEY OF THE pH LIMITS OF AQUATIC PLANTS OF THE WORLD

P.D. Warrington
Biologist
Water Management Branch

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INTRODUCTION

Some literature and known data sources were surveyed to determine the pH and alkalinity limits of aquatic plants under both natural and cultural conditions. Most of the data is from natural ecological conditions; cultural data is sparse. The literature survey is by no means complete, and is strongly biased toward north-temperate species and conditions, but is representative of the kind of pH and alkalinity data available in the literature. Only the portions of the papers pertinent to aquatic plant pH and alkalinity data was abstracted in the review and much other useful information exists in many of these papers and data sources.

Many marginal or seasonally inundated species are included in this review in addition to obligate aquatics. It is commonly observed that with increasing latitude and altitude that marginals move into deeper water. Plants that are marginal in a temperate or sub-tropical setting may become aquatic in boreal or north-temperate sub-alpine situations. There is no satisfactory delimitation of what is or is not an aquatic plant. Generally experience in British Columbia and the treatment by C.D.K. Cook in "Waterplants of the World" were used to determine what species to include. Bog, swamp and fen species were generally omitted unless they also grew as emergent or submerged aquatics in open water situations.

In the abstracts the taxonomy of the aquatic plants is generally given as reported in the paper. However, in the tables of species and pH or alkalinity records some personal judgements are made and data is reported under one name. A conservative, lumping approach has usually been taken. For example Hippuris, Ruppia and Zannichellia are regarded as monotypic genera and Scirpus lacustris and Ranunculus aquatilis are both taken "sensu lato". The following list gives the pertinent taxonomic judgements which are made so that one will know where to find the cumulative data on a taxon. Since the bibliographic reference number is appended to the pH and alkalinity data in the tables it is easy to determine what taxonomic decisions have been made. One can expect some taxonomic and identification problems in the following genera in particular: *Chara*, *Nitella*, *Isoetes*, *Carex*, *Scirpus*, *Eleocharis*, *Cyperus*, *Juncus*, *Lemna*, *Wolffia*, *Najas*, *Nuphar*, *Utricularia*, *Ranunculus*, *Polygonum*, *Callitriche*, *Ludwigia*, *Sparganium* and *Sagittaria*.

LIST OF SYNONYMS

Literature	This Paper
Alisma subcordatum	*Alisma plantago-aquatica*
Amblystegium fluviatile	*Hygroamblystegium fluviatile*
Amblystegium kochii	*Lepidodictyum kochii*
Amblystegium riparium	*Lepidodictyum riparium*
Anacharis canadensis	*Elodea canadensis*
Anacharis densa	*Egeria densa*
Anacharis nuttallii	*Elodea nuttallii*
Anacharis occidentalis	*Elodea nuttallii*
Bidens beckii	*Megalodonta beckii*
Callitriche autumnalis	*Callitriche hermaphroditica*
Castalia tuberosa	*Nymphaea tuberosa*
Crassula aquatica	*Tillaea aquatica*
Elatine minima	*Elatine triandra*
Eleocharis fallax	*Eleocharis palustris*
Eleocharis mamillata	*Eleocharis palustris*
Elodea densa	*Egeria densa*
Elodea occidentalis	*Elodea nuttallii*
Hippuris spp.	*Hippuris vulgaris*
Isnardia spp.	*Ludwigia* spp.
Jussiaea spp.	*Ludwigia* spp.
Lilaea subulata	*Lilaea scilloides*
Ludwigia repens	*Ludwigia palustries*
Myosotis palustris	*Myostis scorpioides*
Myriophyllum brasiliense	*Myriophyllum aquaticum*
Myriophyllum elatinoides	*Myriophyllum quitense*
Nasturtium officionale	*Rorippa nasturtium-aquaticum*
Nelumbo lutea	*Nelumbo pentapetala*
Nymphozanthus microphyllus	*Nuphar microphyllum*
Nymphozanthus rubrodiscus	*Nuphar rubrodiscum*
Nymphozanthus variegatus	*Nuphar variegatum*
Octodiceras fontanum	*Fissidens fontanum*
Phragmites australis	*Phragmites communis*
Polygonum coccineum	*Polygonum amphibium*
Potamogeton americanus	*Potamogeton nodosus*
Potamogeton angustifolis	*Potamogeton illinoensis*
Potamogeton berchtoldii	*Potamogeton pusillus*
Potamogeton capillaceus	*Potamogeton diversifolius*
Potamogeton compressus	*Potamogeton friesii*
Potamogeton dimorphus	*Potamogeton diversifolius*
Potamogeton fibrillosus	*Potamogeton foliosus*
Potamogeton filiformis	*Potamageton pectinatus*

Potamogeton lucens	*Potamogeton alpinus*
Potamogeton mucronatus	*Potamogeton friesii*
Potamogeton panormitanus	*Potamogeton pusillus*
Potamogeton richardsonii	*Potamogeton perfoliatus*
Potamogeton vaginatus	*Potamogeton pectinatus*
Potamogeton zosterifolius	*Potamogeton zosteriformis*
Ranunculus circinatus	*Ranunculus aquatilis*
Ranunculus gmelinii	*Ranunculus flabellaris*
Ranunculus lobbii	*Ranunculus aquatilis*
Ranunculus longirostris	*Ranunculus aquatilis*
Ranunculus subrigidus	*Ranunculus aquatilis*
Ranunculus trichophyllus	*Ranunculus aquatilis*
Ruppia spp.	*Ruppia maritima*
Sagittaria isoetiformis	*Sagittaria teres*
Schoenoplectis spp.	*Scirpus* spp.
Scirpus acutus	*Scirpus lacustris*
Scirpus heterochaetus	*Scirpus lacustris*
Scirpus mamilatus	*Eleocharis palustris*
Scirpus paludosus	*Scirpus maritimus*
Scirpus palustris	*Eleocharis palustris*
Scirpus rubrotinctus	*Scirpus microcarpus*
Scirpus tabernaemontanus	*Scirpus lacustris*
Scirpus validus	*Scirpus lacustris*
Sparganium americanum	*Sparganium eurycarpum*
Sparganium chlorocarpum	*Sparganium angustifolium*
Sparganium emersum	*Sparganium angustifolium*
Sparganium ramosum	*Sparganium eurycarpum*
Sparganium simplex	*Sparganium angustifolium*
Utricularia biflora	*Utricularia gibba*
Utricularia fibrosa	*Utricularia gibba*
Vallisneria americana	*Vallisneria spiralis*
Vallisneria asiatica	*Vallisneria spiralis*
Wolffia papulifera	*Wolffia brasiliensis*
Wolffia punctata	*Wolffia borealis*
Zannichellia spp.	*Zannichellia palustris*
Zosterella dubia	*Heteranthera dubia*

ANNOTATED BIBLIOGRAPHIES

1. McLay, C.L. 1976. The Effect of pH on the Population Growth of Three Species of Duckweed: *Spirodela oligorrhiza*, *Lemna minor* and *Wolffia arrhiza*. Freshwater Biology 6:125-136.

The species were grown in flasks and culture medium (Jacob's), aseptically, at 25°C and 660 ft. cnd. (7 100 lx), for two weeks. Growth rates dropped drastically at the alkaline or acidic limits of about pH 11 and pH 3 but was still good between pH 4 and pH 10. When the pH was held constant, by regular changing and adjusting with NaOH or HCl, but not buffered, growth rates peaked at pH 5.0 for *Wolffia*, pH 6.2 for *Lemna* and pH 7.0 for *Spirodela*.

Growth in buffered solutions was not as good; the buffers themselves probably affecting growth. Growth in unbuffered and unregulated solutions did not give much data on pH limits since the plants themselves altered the pH's of the media towards optimum conditions.

It is difficult to determine the tolerance limits of duckweeds under experimental conditions. The effects of pH may be to influence: the availability of essential nutrients (under alkaline conditions plants have greater difficulty in obtaining iron), the solubility of toxic elements, or the behavior of sensitive root cells to the toxic hydrogen ion. The influence of a specified pH change on plant growth is likely to be environmentally specific. Care must be taken when extrapolating from laboratory to field conditions.

2. Hellquist, C. Barre. 1980. Correlation of Alkalinity and the Distribution of *Potamogeton* in New England. Rhodora 82:331-344.

The data collected from locations where *Potamogeton* was found to grow included pH, total alkalinity, free carbon dioxide, nitrates, total phosphates and chlorides. Since total alkalinity had the highest correlation with the other factors and *Potamogeton* distribution, only total alkalinity

Potamogeton species	N	HCO_3^- Alkalinity	
		Mean	Range
P. *diversifolius* paf.	1	2.4	2.4
P. *confervoides* Reichenb.	12	4.2	0.6-8.5
P. *bicupulatus* Fern.	32	7.6	1.8-25.6
P. *oakesianus* Robbins	33	8.8	2.4-24.4
P. *pulcher* Tuckerm.	21	11.7	3.7-46.4
P. *lateralis* Morong.	1	16.5	16.5
P. *spirillus* Tuckerm.	78	19.2	3.1-70.2
P. *vaseyi* Robbins	11	26.6	8.5-54.9
P. *robbinsii* Oakes	49	28.8	3.7-122.0
P. *epihydrus* Raf.	169	25.5	2.4-161.7
P. *gramineus* L.	117	34.1	3.1-150.7
P. *amplifolius* Tuckerm.	78	35.6	4.3-150.7
P. *perfoliatus* L.	46	36.3	6.1-167.8
P. *pusillus* L.	172	40.3	3.1-206.3
P. *natans* L.	152	41.4	3.1-161.7
mean of all sampling stations	321	43.0	0.6-282.5
P. *alpinus* Balbis	42	49.5	4.9-140.3
P. *richardsonii* (Bennett) Rydb.	27	53.2	16.5-130.6
P. *praelongus* Wulf.	39	56.4	9.8-150.7
P. *obtusifolius* Mert. & Koch	18	58.3	16.5-127.5
P. *zosteriformis* Fern.	74	60.2	5.5-150.7
P. *foliosus* Raf.	62	77.1	17.1-167.8
P. *illinoensis* Morong.	24	82.9	24.4-150.7
P. *filiformis* Pers.	13	83.3	29.3-107.4
P. *strictifolius* Bennett	5	84.8	67.1-109.8
P. *crispus* L.	31	84.9	14.6-207.5
P. *friesii* Rupr.	11	86.9	42.7-150.7
P. *nodosus* Poir.	20	88.8	6.1-282.5
P. *pectinatus* L.	26	114.5	36.6-282.5
P. *vaginatus* Turcz.	1	125.7	125.7
P. *hillii* Morong.	2	148.6	135.5-161.7

data was presented in this paper. The alkalinity was expressed as HCO_3^-. A total of 321 locations in Maine, Vermont, New Hampshire, Massachusettes, Rhode Island and Connecticut were sampled. The following table of means, ranges and sample sizes was modified from that given in the paper by combining subspecific taxa and ranking by mean alkalinity.

3. Lazarek, S. 1982. Structure and Productivity of Epiphytic Algal Communities on Lobelia dortmanna L. in Acidified and Limed Lakes. Water, Air and Soil Pollution 18: 333-342.

Two Swedish lakes were studied; Gardsjon, which is acidified, and Hogsjon, which was limed. The littoral zones of these two lakes are dominated by Lobelia dortmanna in the 0-4 m range (optimally 0.5-1 m depth). Littorella uniflora is common in Hogsjon as well. The pH in Gardsjon ranged from 4.3-4.7 while in Hogsjon it changed from 4.2-5.3 to 6.3-6.7 after liming. Alkalinity in Gardsjon ranged from 6.2-8.1 while in Hodgjon it changed from 0 to 0.13-0.19 after liming.

Benthis and epiphytic algae increased in biomass in lakes undergoing acidification, possibly due to reduced microbial decomposition and reduced invertebrate grazing. Algal community structure changes during acidification; the change may be permanent. The rapid change from acid to neutral during liming may be harmful to these communities.

4. Hendrey, G.R., K. Baalsrud, T.S. Traanen, M. Loake and G. Raddum. 1976. Acid Precipitation: Some Hydrobiological Changes. Ambio 5:224-227.

Bacterial activity decreases as the pH drops and fungi take over as decomposers. Decomposition of leaf litter is greatly reduced, as is oxygen utilization. The mineral sediments are covered by organic debris and nutrients are trapped in the organic layer.

Zooplankton and crustacean species numbers drop with decreasing pH. The amphipod, Gammarus lacustris, an important part of trout diets, is not found below pH 6.0; adult amphipods cannot tolerate 48 hours at pH 5.0.

The emergence of aquatic insects is affected below pH 5.5. Snails were absent from 832 lakes with pH's below 5.2, rare between pH 5.2 and pH 5.8 and less frequent in the range pH 5.8-6.6 than in neutral or alkaline waters.

Fish, particularly salmonids, decrease with decreasing pH. In adult fish the mechanism is apparently failure of body-salt regulation; low serum calcium during ovary maturation leads to reproductive failure at low pH.

Sediment cores, including rooted plants of Lobelia dortmanna were grown at 3 pH levels; 4.0, 4.3-5.5 and 6.0. The growth and productivity of the plants were reduced by 75% at pH 4.0 compared to the controls at 4.3-5.5 and flowering was delayed 10 days. Lobelia and Isoetes dominated lakes, change to Sphagnum dominated lakes as the pH drops. Sphagnum can not utilize HCO_3^- but relies on CO_2 for photosynthesis.

5. Grahn, O., H. Hultberg and L. Lander. 1974. Oligotrophication - A Self-Accelerating Process in Lakes Subjected to Excessive Supply of Acid Substances. Ambio 3(2):93-94.

The buffer system of some Swedish lakes is strong-acid based with sulphate replacing bicarbonate as the major anion; alkalinity is near zero and calcium is not available. The original Lobelia and Isoetes communities have been replaced by Sphagnum spp. with the drop in pH. The replacement is faster in the littoral (0-2 m) zone but also occurs in the deeper (4-6 m) zone. These lakes were all over pH 6.0 in 1948 but had dropped below pH 5.0 by 1973. No molluscs or May Flies were found and fish species were reduced after the pH dropped. Eels and perch were most resistant to low pH, roach least resistant. Total fish biomass decreased and thus agile predatory insects increased. This leads to a shorter food chain and more amplitude in population fluctuations.

6. Gosling, L.M. and S.J. Baker. 1980. Acidity Fluctuations at a Broadland Site in Norfolk. Journ. of Applied Ecol. 17:479-490.

Soils rich in pyrites were subjected to alternate drying and saturation. This lead to oxidation of the pyrite and the production of sulphuric acid. Pulses of acid formation caused the pH of the water to drop from the normal, near neutral 7.4 to pH 3.2.

Emergent plants like *Phragmites australis*, *Iris pseudacorus*, *Acorus calamus*, *Menyanthes trifoliata*, *Typha latifolia* and *Alisma plantago-aquatica* were not noticeably affected by the low pH pulse. Floating or submerged plants which still survived after the low pH pulse included *Hippuris vulgaris*, *Hottonia palustris*, *Nuphar lutea* and *Nymphaea alba*. *Luronium natans* grew prior to the acid pulse but did not recolonize. The other species present prior to the acid pulse, which died out at the low pH's, recolonizd later. They included *Callitriche stagnalis*, *Ceratophyllum demersum*, *Elodea canadensis*, *Hydrocharis morsus-ranae*, *Stratiotes aloides*, *Myriophyllum* sp. and *Potamogeton* sp.

7. Titus, J.E. and W.H. Stone. 1982. Photosynthetic Response of Two Submersed Macrophytes to Dissolved Inorganic Carbon Concentration and pH. Limnol. Oceanogr. 27(1):151-160.

Carbon uptake of *Vallisneria americana* declines by 61% from pH 7 to pH 8, but changes little between pH 8 and pH 9. For *Myriophyllum spicatum* the respective declines are 35% and a further 58%. These decreases are not proportional to the decline in free CO_2 over this pH range. Carbon compensation points (total DIC, free CO_2 or atmospheric CO_2 in equilibrium with free CO_2) are strongly pH dependent.

8. Roelofs, J.G.M., J.A.A.R. Schuurkes and A.J.M. Smits. 1984. Impact of Acidification and Eutrophication on Macrophyte Communites in Soft Water. II. Experimental Studies. Aquatic Botany 18:389-411.

Ammonium, nitrate and orthophosphate uptake rates of Littorella uniflora and Juncus bulbosus were not affected by pH or alkalinity over the range pH 3.5-6.5. Ammonia is used preferentially unless the plants are nitrogen starved for 7-14 days after which nitrate is also used to some extent. Nitrogen and phosphorus uptake rates increased with incubation time in nitrogen and phosphorus free media. Litorella excreted potassium but Juncus took it up.

Increased phosphate levels in the water lead to epiphyte blooms which reduce macrophyte biomass. Riccia fluitans increases under higher phosphate but unacidified water conditions. If the water is phosphate free and the sediments enriched then Myriophyllum alternifolorum thrives; but if the water is enriched with phosphate then filamentous algae take over.

Changes in plant communities in these soft waters are mainly due to changed carbon and/or nitrogen budgets resulting from acidification. In non-acidified, poorly buffered, oligotrophic waters, the CO_2 levels are 10-100 times higher. Plants which can grow under these conditions, Littorella uniflora, Isoetes lacustris and Lobelia dortmanna, take up CO_2 by the roots, release O_2 from the roots and have high root biomass at low sediment CO_2 levels. Juncus bulbosus does not have these adaptations.

When such waters are acidified and there is little carbonate in the sediment, a temporary CO_2 increase occurs in the sediments (10 µmol/l), and diffuses to the water column. Under these conditions Juncus bulbosus and Sphagnum spp. may grow and suppress the Littorella, Isoetes and Lobelia. However, if the sediment initially contained carbonate the Littorella increased at each pH level. Inorganic carbon budgets are dependent upon the sediment carbonate content.

- acidification of the water is the main cause for the decline of Littorella, Isoetes and Lobelia.

- acidification over non-buffered, carbonate-free sediment leads to loss of all submerged aquatics due to lack of CO_2.

- if nitrogen and phosphorus are not limited, acidification of water over poorly buffered sediment containing a little carbonate, leads to suppression of *Isoetes*, *Lobelia* and *Littorella* by *Juncus bulbosus* and *Spagnum* spp. due to raised CO_2 in the water.

- the increased ammonium and reduced nitrate in acidified waters, resulting from reduced nitrification, favours *Juncus* over *Isoetes*, *Lobelia* and *Littorella*.

- in non-acidified water with increased alkalinity, enriching only the sediment with phosphate leads to growth enhancement of rooted plants like *Myriophyllum alterniflorum*. Enriching both sediment and water column leads to growth of non-rooted plants like *Riccia fluitans* in shallow ponds and planktonic blooms and benthic algal growth in larger and deeper bodies of water.

9. Wetzel, R.G., E.S. Brammer and C. Forsberg. 1984. Photosynthesis of Submersed Macrophytes in Acidified Lakes. I. Carbon Fluxes and Recycling of CO_2 in *Juncus bulbosus* L. Aquatic Botany 19:329-342.

As soft-water lakes become more acidic the biomass and rates of carbon fixation by phytoplanktonic algae is reduced along with species diversity. Benthic algae and mosses, particularly *Sphagnum auriculatum*, increase and move out from littoral areas to deeper water (to 15 m). At pH's near 5 aquatic plants like *Lobelia dortmanna*, *Isoetes lacustris*, *Littorella uniflora* and *Juncus bulbosus* are common and dominate the macrophyte flora of these soft-water lakes.

At pH's below 5 HCO_3^- ions are nearly absent and inorganic carbon is available mainly as dissolved CO_2. The CO_2 concentration, in equilibrium with the atmosphere, is very low and diffusion rates in water are quite slow. Thus aquisition of carbon can become the rate limiting step in photosynthesis. The CO_2 from respiration is recycled and that found in internal gas lacunae is also vital for efficient photosynthesis in *Juncus bulbosus*; at least 50% of the CO_2 fixed is derived from recycled CO_2.

10. Haines, T.A. 1980. Acidic Precipitation. Fisheries 5(6):2-5.

When the buffering capacity of a watershed is exhausted, lakes and streams reflect the pH of the precipitation. Acidic lakes have higher concentrations of metals than similar non-acidic lakes. The metals are found in the precipitation and are also leached from soils and sediment by the acids in the runoff water. Aluminum is not found in rainfall but is leached by acidic precipitation and found at very high levels in acidic lakes. Spring snow-melt can cause severe depressions in lake pH and increases in metal content. Conntaminants are stored in the snowpack and released all-at-once during snow-melt, with most of the metal concentrated in the first stage of the melt. The pH may drop to 3.8, and aluminum rise to 1 mg/l during the early pulse. The phytoplankton species composition shifts from chlorophyte and chrysophyta to pyrrophyta; Sphagnum mats increase, displacing other macrophytes, as the pH of the lake decreases.

11. Ondok, J.P., J. Pokorny and J. Kvet. 1984. Model of Diurnal Changes in Oxygen, Carbon Dioxide and Bicarbonate Concentrations in a stand of Elodea canadensis Michx. Aquatic Botany 19:293-305.

The diurnal pH range in a stand of Elodea canadensis, caused by photosynthesis and respiration affecting dissolved organic carbon levels, varied from a high of 10.0 at mid-day to a low of 7.0 at night.

12. Malme, Leif. 1978. Floristic and Ecological Studies of Bryophytes in Some Norwegian Island Lakes. Norw. Journ. Bot. 25:271-279.

The Bryophytes of 23 Norwegian lakes were surveyed and, among other parameters, pH was also measured. The table below gives the pH ranges for the 36 mosses and 10 liverworts found.

Species	pH Range
Anthelia jubacea (L.) Dam	5.7-5.9
Blindia acuta (Hedw.) B.S.G.	5.3
Brachythecium rivulare B.S.G.	6.3-6.9
B. rutabulum (Hedw.) B.S.G.	6.8
Calliergon cordifolium (Hedw.) Kindb.	6.7-6.9
C. giganteum (Schimp.) Kindb.	6.9
C. sarmentosum (Wahl.) Kindb.	6.3
Calliergonella cuspidata (Hedw.) Loesk	6.3-7.2
Campylium stellatum (Hedw.) C. Jens	6.3-6.4
Chiloscyphus pallescens (Ehrh.) Dun.	6.9
Cinclidium stygium Sw.	6.9
Climacium dendroides (Hedw.) Web. et Mohr.	6.3-7.0
Dicranella palustris (Dicks) Crundw.	6.3
Drepanocladus aduncus (Hedw.) Warnst.	6.3-7.0
D. exannulatus (B.S.G.) Warnst.	5.6-7.2
D. fluitans (Hedw.) Warnst.	5.7-7.0
D. revolvens (Sw.) Warnst.	6.8-7.0
D. trichophyllus (Warnst.) Podp.	5.6-5.7
Fissidens osmondoides Hedw.	6.3-7.2
F. adianthoides Hedw.	6.8-7.0
Fontinalis antipyretica Hedw.	5.6-7.2
F. hypnoides Hartm.	5.6-6.9
F. squamosa Hedw.	5.6-7.1
F. dalecarlica B.S.G.	5.7
Hygrohypnum luridum (Hedw.) Jenn.	6.9
H. ochraceum (Wils.) Loesk.	5.7-7.1
Jungermania sphaerocarpa Hook.	5.3
Marchantia polymorpha L.	6.3-6.9
Marsupella emarginata (Ehrh.) Dum.	5.2-6.3
Meersia triquetra (L.) Aongstr.	6.8-6.9
Mniobryum wahlenbegia (Web. et Mohr.) Jenn	5.9-6.6
Mnium ciclidioides Hueb.	6.8-6.9
M. punctatum Hedw.	6.9
Mylia taylorii (Hook.) Gray	5.9
Nardia compressa (Hook.) Gray	5.3-5.9
Philonotis fontana (Hedw.) Brid.	5.7-7.0
Racomitrium aciculare (Hedw.) Brid.	5.9-7.2
Scapania dentata Dum.	5.3-6.6
S. uliginosa (Sw.) Dum.	5.3-5.7
S. undulata (L.) Dum.	5.3-7.1
Scorpidium scorpioides (Hedw.) Limpr.	6.6-6.9
Spagnum cuspidatum Hoffm.	5.6-6.9
S. pulchrum (Lindb.) Warmst.	6.4
S. squarrosum Crom.	6.6
S. subsecundum Nees.	5.6-6.9
Splachnum vasculosum L. ex Hedw.	5.3-5.7

13. Hendrey, G.R. and F.A. Vertucci. 1980. Benthic Plant Communities in Acidic Lake Colden, New York: *Sphagum* and the Algal Mat. Proc. Int. Conf. Ecol. Impact Acid. Precip. Norway.

Species lists for Lake Colden in 1932 and 1979 were compared. The 1979 pH was about 4.9 but the 1932 pH, while expected to be much higher, is not known. The cover of the plants in 0.5 m depth contours was plotted. The species present in 1979 included:

Abundant: *Potamogeton confervoides*, *Scirpus subterminalis*, *Eriocaulon septangulare*, *Sphagnum pylaesii*, *Utricularia* sp.
Common: *Myriophyllum tenellum*, *Isoetes muricata*
Frequent: *Drepanocladus exannulatus*
Rare: *Eleocharis acicularis*, *Nuphar luteum*, *Lobelia dortmanna*, *Vallisneria americana*, *Sphagnum cuspidatum*

14. Sculthorpe, C.D. 1967. The Biology of Aquatic Vascular Plants. Edward Arnold Ltd. London.

Eleocharis sellowiana grows in a crater lake in El Salvador. This lake is fed by sulphurous springs and the pH may drop as low as 2.0. *Salvinia auriculata* grows in Lake Kariba, Africa at a pH of 7.4, in other parts of Africa at pH's between 6.8 and 9.5 and in Malaya at an average pH of 5.2. Reproduction is vegetative-only at the lower pH of Malaya where only microsporocarps are produced. Photosynthesis in *Myriophyllum spicatum* is independent of pH in the range 4.0-10.0 when CO_2 is the carbon source but highly pH dependent if HCO_3^- is the source of carbon.

15. Nielson, E.S. 1946. Carbon Sources in the Photosynthesis of Aquatic Plants. Nature 1158:594-596.

Fontinalis can not utilize HCO_3^-, but must use CO_2; most other species do use HCO_3^- as a carbon source. *Myriophyllum spicatum* grows at pH 4.6 where 99% of the carbon is in the CO_2 phase, and still maintains a constant rate of photosynthesis down to pH 2.9. Below 2.9 the rate decreases with time. The rate is independent of pH over the range 4.0-10.00.

16. Pieterse, A.H., L. DeLange and L. Verhagen. 1981. A Study on Certain Aspects of Seed Germination and Growth of Pistia stratiotes L. Acta. Bot. Neerl. 30:47-57.

Pistia stratiotes plants were grown in a greenhouse on clay in tapwater and the seeds harvested. Several seed germination tests were carried out under different depth, temperature and storage regimes. Growth was carried out at various pH values on Long-Ashton medium at 25°C and on partial tapwater with rainwater or medium. The pH was adjusted daily. Pistia grew between pH 4.0 and pH 10.0,. but poorly below 5 and above 8, and optimally at 7.0 Eichhornia crassipes outcompetes Pistia at pH 4.

17. Yutaka, N. and M. Kugimoto. 1981. Lemna (Duckweed) as an Indicator of Water Pollution. I. The sensitivity of Lemna paucicostata to Heavy Metals. Arch. Environ. Contam. Toxicol. 10:159-169.

An asceptic laboratory strain of Lemna paucicostata was grown in artificial media at several pH's. Values of 4.1, 5.1, 6.1 and 7.1 were used. Lemna grew well at all these pH's under the cultural conditions.

18. Raven, J., J. Beardall and H. Griffiths. 1982. Inorganic C - Sources for Lemanea, Cladophora and Ranunculus in a Fast-Flowing Stream: Measurements of Gas Exchange and of Carbon Isotope Ratio and their Ecological Implications. Oecologia 53:68-78.

Experimental work on photosynthesis, including work on Ranunculus penicillatus, was carried out at pH 6.5 and pH 8.0. The pH was allowed to drift in some experiments and rose as far as 10.3.

19. Wetzel, R.G. 1967. Factors Influencing Photosynthesis and Excretion of Dissolved Organic Matter by Aquatic Macrophytes in Hard-Water Lakes. Verh. Internat. Verein. Limnol. 17:72-85.

In addition to the other experiments described, Najas flexilis was grown successfully at pH's from 7.0 to 8.8.

20. Smock, L.A., D.L.Stoneburner and D.R. Lenat. 1981. Littoral and Profundal Macroinvertebrate Communites of a Coastal Brown-Water Lake. Arch. Hydrobiol. 92(3):306-320.

Stoneburner, D.L. and L.A. Smock. 1979. The Physical and Chemical Limnology of an Insular, Brown-Water Lake in Coastal Georgia. Arch. Hydrobiol, 87(3):364-378

Lake Whitney on Cumberland Island, a barrier island off the coast of Georgia, is in a dune area and has no surface drainage. One shore is steep-sided, unstable dunes, the other a *Spartina*-*Juncus* marsh. The lake is poorly buffered, acidic, highly coloured, nutrient poor and polymictic. Some morphometric and physical/chemical parameters include: surface area, 1.82 km^2; mean depth, 1.6 m; maximum depth, 2.3 m; annual surface temperature range, 8-28°C; surface pH range, 3.5-5.9; colour (average), 176 Pt.; mean annual total calcium, 1.32 mg/L and mean annual total magnesium, 0.73 mg/L.

The macrophytes present included *Limnobium spongia*, *Utricularia biflora*, *Alternanthera philoxeroides*, *Scirpus americanus*, *Ceratophyllum echinatum*, *Polygonum punctatum*, *P. hydropiperoides*, *Paspalum fluitans*, *Hydrocotyle bonariensis*, *Pontedaria cordata*, *Typha latifolia*, *Nelumbo lutea*, *Brasenia schreberi*, *Nymphaea odorata* and *Nymphoides aquatica*.

21. Wile, I. 1980. Unpublished Data. Limnology and Toxicity Section, Ontario Ministry of the Environment, Rexdale, Ontario.

Surveys of the aquatic flora of 31 Canadian Shield lakes by the Ontario Ministry of the Environment in 1978-1979 resulted in the data in the table below which shows the pH range at which a number of species were found to grow.

Species	No. of lakes with occurrences	ph range
Brasenia schreberi Gmel.	19	4.0 - 7.6
Elatine minima (Nutt.) Fisch. & Meyer	11	4.7 - 7.0
Eleocharis acicularis (L.) R. & S.	26	4.3 - 7.0
Eriocaulon septangulare With.	29	4.3 - 7.6
Isoetes sp.	24	4.3 - 7.0
Juncus militaris Bigelow	18	4.3 - 7.6
Juncus pelocarpus Meyer	18	4.4 - 7.6
Lobelia dortmanna L.	23	4.4 - 7.0
Lycopus sp.	21	4.0 - 6.7
Myriophyllum tenellum Bigelow	18	4.4 - 7.6
Nitella flexilis (L.) Ag. (1)	5	5.5 - 7.6
Nitella tenuissima (Desv.) Kutz.	7	4.8 - 7.0
Nuphar variegatum Englm.	24	4.0 - 7.6
Nymphoides cordatum (Ell.) Fernald	8	4.4 - 6.1
Nymphaea odorata Ait.	22	4.0 - 7.6
Pontederia cordata L.	27	4.0 - 7.6
Potamogeton berchtoldii Fieber	5	4.8 - 6.8
Potamogeton confervoides Reichenb.	7	4.3 - 4.8
Potamogeton epihydrus Raf.	23	4.0 - 7.6
Potamogeton natans L.	5	4.3 - 5.6
Potamogeton oakesianus Robbins	10	4.3 - 6.0
Ranunculus reptans L.	13	4.6 - 6.4
Sagittaria sp.	10	4.5 - 7.0
Sparganium sp.	25	4.0 - 6.7
Utricularia purpurea Walt.	18	4.3 - 7.6
Utricularia resupinanta B.D. Greene	16	4.4 - 7.6
Utricularia vulgaris L.	23	4.0 - 7.6
Vallisneria americana Michx.	5	5.5 - 7.0
Fontinalis sp. (1)	28	4.0 - 7.0
Sphagnum spp.	17	4.0 - 6.7

NOTE: the following species occurred in less than four lakes: *Callitriche* sp., *Ceratophyllum demersum*, *Chara* sp., *Cladopiella* sp., *Drepanocladus* sp., *Elodea canadensis*, *Galium* sp., *Hypericum* sp., *Juncus* sp., *Myriophyllum alterniflorum*, *M. farwelli*, *Nitella acumiminata*, *Nitella furcata*, *N. gracilis*, *Polygonum amphibium*, *Potamogeton amplifolius*, *P. capillaceus*, *P. confervoides*, *P. foliosus*, *P. obtusifolius*, *P. pusillus*, *P. richardsonii*, *P. robbinsii*, *P. spirillus*, *P. vaseyi*, *Utricularia cornuta*, *U. gemniscapa* *U. gibba*, *U. intermedia*, *U. minor*, *Viola lancelota*.

(1) The low end of the pH range of these species is represented by a dystrophic lake.

22. Glaser, P.H., G.A. Wheeler, E. Gorham and H.E. Wright. 1981. The Patterned Mires of the Red Lake Peatland, Northern Minnesota: Vegetation, Water Chemistry and Landforms. Journ. of Ecol. 69:575-599.

While most of the paper deals with peat bog and fen vegetation, some aquatic species were also encountered and pH data is available for these plants. The data was extracted from the phytosociological tables and is presented below.

Species	pH of releves	pH range
Utricularia intermedia	6.5, 6.0, 6.2, 6.2, 6.9, 6.2, 6.1, 5.9, 5.7, 4.6, 6.5, 6.0	4.6 - 6.9
Menyanthes trifoliata	6.5, 6.0, 6.2, 6.2, 6.9, 6.2, 6.1, 5.9 5.7, 4.6, 6.5, 6.0, 6.0, 5.9, 6.0, 6.4 5.5, 6.0, 5.2, 6.2	4.6 - 6.9
Utricularia minor	6.9, 6.2, 6.1, 5.9	5.9 - 6.9
Potentilla palustris	6.0, 6.2, 5.9, 4.3, 4.4, 6.0, 6.4, 5.5 6.0, 5.2, 6.3, 6.2	4.3 - 6.3
Lysimachia thyrsiflora	6.5, 6.0, 6.0, 6.4, 5.5, 6.0, 6.3	5.5 - 6.5
Calla palustris	6.0, 6.0, 6.4, 5.5, 6.0, 5.2, 6.3, 6.2	5.2 - 6.4
Utricularia cornuta	6.9, 4.6	4.6 - 6.9
Cicuta bulbifera	6.0, 6.4	6.0 - 6.4
Potamogeton gramineus	6.1, 6.2	6.1 - 6.2
Ranunculus gmelinii	6.4	6.4
Scirpus cespitosis	6.5, 6.0, 6.0, 6.2	6.0 - 6.5

23. Weber, J.A., J.D. Tenhunen, S.S. Westrin, C.S. Yocum and D.M. Gates. 1981. An Analytical Model of Photosynthetic Response of Aquatic Plants to Inorganic Carbon and pH. Ecology 62(3):697-705.

Data on the measured responses of Hydrodictyon africanum and Chara corallina was used to calibrate the model. These algal species were found to grow well at pH's of 5.7, 7.3 and 9.8 for Hydrodictyon and 5.3 and 9.1 for Chara.

24. McLay, C.L. 1974. The distribution of duckweed Lemna perpusilla in a small Southern California lake: an experimental approach. Ecology 55:262-276.

In a small alkaline lake in California Lemna perpusilla Torr. distribution is influenced by a number of factors including: shading by Scirpus californicus (C.A. Mey) Steud., stranding on mud as water levels fluctuate, and pH differences in different parts of the lake. The pH in areas where growth was favoured was 7.7 while the less favourable areas had a pH of 8.2

25. Warrington. P.D. 1986. Unpublished Data. Water Management Branch, Ministry of Environment, British Columbia.

The author maintains a computerized data base on the aquatic plants of British Columbia. Data included is comprised of various aspects of lake morphometry, lake surface water chemistry, lake sediment chemistry, geographical and ecological data on the lakes, and the presence or absence of 140 species of aquatic plants found in British Columbia. Over 1 450 bodies of water have been partially or completely surveyed; over 1 160 of these are lakes, over 200 ponds and the rest rivers, sloughs, wetlands and other bodies of water. Aquatic mosses, grasses and species of Carex have not been systematically collected and are not adequately represented in the data base. This data base is constantly updated as new information becomes available. The tables below give the pH and alkalinity data, as of June 19, 1986, from this data set.

Calculations based on this pH and alkalinity data from 413 lakes in British Columbia give a Pearson Correlation coefficient of 0.915 and the regression equation below.

$$\log_{10} \text{alkalinity} = 0.69 \text{ pH} - 3.62$$

Most of the spread of alkalinity at a given pH is within $\pm 0.25 \log_{10}$ alkalinity. Alkalinity is expressed as $CaCO_3$/L.

pH Data

Species	min. pH	mean pH	max. pH	Std. dev.	N
Acorus calamus	6.5	7.8	8.2	0.4	3
Alisma gramineum	6.5	8.2	8.9	0.4	6
Alisma plantago-aquatica	5.6	7.8	10.2	0.6	22
Azolla filiculoides	6.5	8.2	7.4	-	1
Bidens beckii	5.6	7.6	9.2	0.5	16
Brasenia schreberii	5.6	7.3	10.0	0.7	33
Calla palustris	6.5	7.5	9.0	0.6	21
Callitriche anceps	5.6	7.8	9.2	0.8	6
Callitriche hermaphroditica	5.6	7.5	9.2	0.4	31
Callitriche heterophylla	5.6	7.2	9.2	0.4	38
Callitriche stagnalis	6.0	7.5	9.1	0.5	9
Callitriche verna	6.0	7.5	8.8	0.5	6
Ceratophyllum demersum	5.6	7.9	10.0	0.6	71
Ceratophyllum echinatum	6.5	7.2	8.0	0.2	12
Cicuta bulbifera	6.4	7.7	8.6	0.5	6
Cicuta douglasii	5.6	7.2	10.0	0.8	32
Dulichium arundinaceum	5.6	7.1	10.0	0.6	58
Eleocharis acicularis	5.6	7.8	9.2	0.5	14
Eleocharis palustris	5.6	7.7	10.2	0.6	106
Elodea canadensis	5.6	7.6	10.0	0.5	68
Elodea densa	6.8	7.0	7.2	-	1
Elodea nuttallii	6.5	6.9	7.5	-	1
Equisetum fluviatile	5.6	7.5	10.2	0.6	137
Equisetum palustre	5.6	7.5	9.2	0.5	19
Fontinalis antipyretica	5.9	7.1	8.5	0.4	57
Gratiola ebracteata	6.5	7.3	7.8	0.3	4
Gratiola neglecta	5.6	7.6	9.2	0.4	6
Heterantha dubia	5.6	8.1	9.2	0.4	14
Hippuris vulgaris	5.0	7.8	10.0	0.6	150
Iris pseudacocus	6.0	7.7	10.0	0.7	16
Juncus supiniformis	3.7	7.1	9.0	0.8	32
Lemna minor	5.6	7.9	10.2	0.7	52
Lemna trisulca	6.0	7.8	10.0	0.6	40
Lilaea scilloides	6.5	6.9	7.5	-	1
Lilaeopsis occidentalis	6.5	7.1	7.8	0.2	5
Limosella aquaticum	5.6	7.5	9.2	0.5	5
Limosella subulata	6.9	6.9	6.9	-	1
Lobelia dortmanna	3.7	7.0	8.9	0.7	44
Ludwigia palustris	6.0	7.6	9.3	0.5	12
Lysimachia thyrsifolora	6.6	7.6	8.5	0.5	34
Marsilea vestita	5.7	7.8	8.7	0.6	3
Menyanthes trifoliata	3.7	7.1	10.0	0.8	99
Mimulus floribundus	5.6	8.2	9.2	-	1
Mimulus glabratus	6.7	7.7	8.9	-	1
Mimulus guttatus	5.6	7.8	10.0	0.6	14

continued

pH Data (Continued)

Species	min. pH	mean pH	max. pH	Std. dev.	N
Montia fontana	7.1	7.5	8.0	-	1
Myosotis laxa	5.6	7.6	10.0	0.6	24
Myosotis scorpioides	6.5	8.0	10.2	0.7	7
Myriophyllum exalbescens	5.6	8.0	10.5	0.6	180
Myriophyllum farwellii	6.3	6.8	7.6	0.4	8
Myriophyllum hippuroides	6.4	7.0	7.8	0.3	4
Myriophyllum quitense	7.1	5.9	7.7	0.2	5
Myriophyllum spicatum	6.5	7.9	9.7	0.5	15
Myriophyllum ussuriense	5.6	7.4	9.2	0.4	8
Myriophullum verticillatum	6.2	7.7	10.0	0.6	44
Najas flexilis	5.6	7.6	10.0	0.6	75
Nuphar polysepalum	3.7	7.3	10.0	0.7	229
Nuphar variegatum	6.5	8.1	8.9	0.5	30
Oenanthe sarmentosa	5.9	7.3	10.0	0.5	27
Polygonum amphibium	5.6	8.1	10.2	0.6	103
Polygonum hydropiper	6.9	7.7	8.7	0.7	7
Polygonum hydropiperoides	7.0	7.9	10.0	0.5	2
Polygonum lappathifolium	8.7	8.7	8.7	-	1
Potamogeton alpinus	5.6	7.6	9.2	0.5	45
Potamogeton amplifolius	5.6	7.5	10.0	0.5	91
Potamogeton berchtoldii	5.6	7.6	10.2	0.6	101
Potamogeton crispus	5.6	7.8	9.7	0.5	22
Potamogeton diversifolius	8.3	8.3	8.3	-	1
Potamogeton epihydrus	3.7	6.8	8.8	0.7	74
Potamogeton fibrillosus	6.8	7.6	8.3	1.1	2
Potamogeton filiformis	6.5	8.0	9.2	0.5	18
Potamogeton foliosis	6.5	7.9	9.0	0.6	14
Potamogeton friesii	5.6	7.7	9.2	0.6	37
Potamogeton gramineus	3.7	7.6	10.0	0.7	165
Potamogeton illinoensis	5.6	8.1	9.2	0.5	15
Potamogeton natans	3.7	7.5	10.0	0.8	159
Potamogeton nodosus	6.3	7.8	9.2	0.7	17
Potamogeton obtusifolius	6.5	7.5	10.0	0.5	9
Potamogeton pectinatus	5.0	8.1	10.2	0.5	147
Potamogeton praelongus	5.6	7.7	10.0	0.7	95
Potamogeton pusillus	5.6	8.1	9.5	0.7	8
Potamogeton richardsonii	5.6	8.0	10.0	0.6	151
Potamogeton robbinsii	5.6	7.4	10.0	0.5	65
Potamogeton strictifolius	7.3	8.0	8.9	0.3	3
Potamogeton vaginatus	5.6	8.1	9.2	0.5	21
Potamogeton zosteriformis	5.6	7.9	10.0	0.6	63
Potentilla palustris	3.7	7.4	10.0	0.7	117
Ranunculus aquatilis	5.6	7.6	10.0	0.6	188
Ranunculus cymbalaria	7.6	8.5	10.3	0.7	7
Ranunculus flabellaris	5.6	7.8	9.2	0.6	7
Ranunculus flammula	3.7	7.3	10.0	0.7	96
Ranunculus gmelinii	5.6	8.1	9.2	0.4	15

continued

pH Data (Continued)

Species	min. pH	mean pH	max. pH	Std. dev.	N
Ranunculus hyperboreus	5.6	8.2	9.2	-	1
Ranunculus sceleratus	6.7	8.1	10.2	0.7	12
Riccia fluitans	6.5	7.4	8.8	0.8	6
Ricciocarpus natans	5.6	8.1	9.2	0.5	6
Rorippa nasturtium-aquaticum	5.6	8.0	9.8	0.7	17
Ruppia maritima	6.4	8.3	10.5	0.8	11
Scirpus americanus	6.6	8.9	10.3	0.7	6
Scirpus fluviatilis	8.1	8.5	8.7	-	1
Scirpus lacustris	5.0	7.9	10.5	0.8	149
Scirpus subterminalis	3.7	6.9	8.8	0.7	52
Sium sauve	5.6	7.7	10.0	0.5	46
Sparganium emersum	3.7	7.3	10.0	0.7	110
Sparganium eurycarpum	5.6	8.1	10.0	0.4	11
Sparganium fluviatilis	5.6	6.5	7.4	0.8	3
Sparganium minimum	3.7	7.3	9.5	0.9	33
Spirodela polyrhiza	5.6	7.8	10.0	0.6	30
Subularia aquatica	5.6	7.2	9.2	0.5	17
Tillaea aquatica	5.6	7.3	9.2	0.5	7
Typha latifolia	5.6	7.7	10.2	0.7	146
Utricularia gibba	6.1	7.2	7.8	0.3	8
Utricularia intermedia	3.7	7.1	8.9	0.8	41
Utricularia minor	5.8	7.2	9.0	0.7	34
Utricularia vulgaris	3.7	7.5	10.2	0.8	169
Vallisneria americana	5.6	7.7	10.0	0.5	10
Veronica americana	5.6	8.0	10.0	0.4	14
Veronica anagallis-aquatica	6.0	7.1	7.9	-	1
Veronica scutellata	5.6	7.2	9.2	0.5	12
Wolffia punctata	8.5	8.5	8.5	-	1
Zannichellia palustris	5.6	8.3	10.5	0.7	23
Genera					
Alisma	5.6	7.9	10.2	0.6	24
Callitriche	5.0	7.3	9.2	0.6	95
Carex	6.2	7.6	9.2	0.7	24
Ceratophyllum	5.6	7.8	10.0	0.6	76
Chara	5.6	7.8	10.2	0.6	159
Eleocharis	5.6	7.7	10.2	0.6	115
Elodea	5.6	7.5	10.0	0.5	70
Equisetum	5.6	7.6	10.2	0.7	142
Glyceria	6.5	7.1	8.1	0.3	2
Isoetes	3.7	7.1	9.2	0.6	89
Lemna	5.6	7.8	10.2	0.6	81
Limosella	6.5	7.3	8.9	0.4	5
Mimulus	5.6	7.7	10.0	0.6	15
Myosotis	5.6	7.8	10.2	0.5	36

continued

pH Data (Continued)

Species	min. pH	mean pH	max. pH	Std. dev.	N
Myriophyllum	5.6	7.9	10.5	0.7	228
Nitella	5.9	7.3	10.0	0.6	33
Nuphar	3.7	7.4	10.0	0.7	263
Nymphaea	5.6	7.4	8.5	0.6	34
Polygonum	5.6	8.1	10.2	0.6	105
Potamogeton	3.7	7.6	10.2	0.8	430
Ranunculus	3.7	7.6	10.3	0.7	231
Sagittaria	5.6	7.7	9.6	0.6	51
Scirpus	3.7	7.8	10.5	0.9	190
Sparganium	3.7	7.4	10.0	0.7	190
Utricularia	3.7	7.5	10.2	0.8	189
Veronica	5.6	7.6	10.0	0.6	28

Alkalinity Data

Species	min. alk.	mean alk.	max. alk.	Std. dev.	N
Acorus calamus	33.7	51.5	69.2	25.1	2
Alisma gramineum	33.7	109.0	250.9	76.5	6
Alisma plantago-aquatica	5.9	83.5	300.6	89.6	19
Azolla filiculoides	-	33.7	-	-	1
Bidens beckii	8.7	48.8	120.7	37.1	11
Brasenia schreberii	0.5	53.8	289.0	70.5	18
Calla palustris	8.7	52.1	130.0	29.5	13
Callitriche anceps	13.5	75.1	191.5	71.7	5
Callitriche hermaphroditica	13.5	42.1	120.7	28.5	25
Callitriche heterophylla	2.8	27.9	120.0	27.8	26
Callitriche stagnalis	6.0	53.6	9.1	23.8	7
Callitriche verna	14.5	40.4	110.0	39.8	5
Ceratophyllum demersum	16.4	80.5	300.6	64.0	53
Ceratophyllum echinatum	16.5	24.8	36.0	7.4	8
Cicuta bulbifera	20.6	71.2	212.0	79.5	5
Cicuta douglasii	3.9	40.7	167.9	43.9	19
Dulichium arundinaceum	0.5	28.0	226.0	41.1	34
Eleocharis acicularis	5.9	61.9	120.7	45.0	10
Eleocharis palustris	4.6	70.2	300.6	64.8	81
Elodea canadensis	5.9	46.8	226.0	41.5	55
Elodea nuttallii	-	5.9	-	-	1
Equisetum fluviatile	3.3	59.8	300.6	59.4	107
Equisetum palustre	8.7	50.1	120.0	39.4	12
Fontinalis antipyretica	4.1	24.7	190.0	30.2	43
Gratiola ebracteata	5.9	21.4	40.1	14.5	4
Gratiola neglecta	24.1	38.9	63.2	19.9	5
Heteranthera dubia	25.6	76.3	151.5	45.5	13
Hippuris vulgaris	1.4	102.5	626.0	94.6	115
Iris pseudacorus	5.9	29.1	62.1	15.9	14
Juncus supiniformis	3.9	19.6	58.1	12.6	13
Lemna minor	16.4	105.7	476.8	96.7	39
Lemna trisulca	19.4	95.9	300.6	70.4	30
Lilaea scilloides	-	5.9	-	-	1
Lilaeopsis occidentalis	5.9	36.2	120.0	47.7	5
Limosella aquatica	5.9	28.0	63.2	25.1	4
Limosella subulata	-	23.1	-	-	1
Lobelia dortmanna	5.9	26.9	148.0	34.9	23
Ludwigia palustris	16.5	52.4	151.5	47.3	9
Lysimachia thyrsiflora	3.9	51.4	225.9	49.0	26
Marsilea vestita	33.7	60.7	112.8	45.2	3
Menyanthes trifoliata	1.7	47.6	289.0	62.0	60
Mimulus floribundus	-	63.2	-	-	1
Mimulus glabratus	-	81.7	-	-	1
Mimulus guttatus	19.4	74.6	300.0	86.7	9
Montia fontana	-	26.3	-	-	1
Myosotis laxa	5.9	62.7	451.5	103.7	18
Myosotis scorpioides	19.4	194.7	451.5	174.4	5

continued

Alkalinity Data

Species	min. alk.	mean alk.	max. alk.	Std. dev.	N
Myriophyllum exalbescens	14.3	106.6	626.0	102.3	127
Myriophyllum farwellii	6.3	14.2	7.6	12.7	2
Myriophyllum hippuroides	5.2	12.9	24.9	9.3	4
Myriophyllum quitense	14.4	16.1	19.4	2.9	3
Myriophyllum spicatum	24.9	79.0	151.5	45.2	14
Myriophyllum ussuriense	5.9	28.1	63.2	19.3	7
Myriophyllum verticillatum	4.1	97.2	299.0	90.7	37
Najas flexilis	0.5	56.5	300.6	58.2	53
Nuphar polysepalum	1.7	43.5	289.0	49.3	155
Nuphar variegatum	24.8	103.8	250.9	71.8	24
Oenanthe sarmentosa	5.9	37.9	107.3	28.2	20
Polygonum amphibium	8.7	124.0	626.0	112.5	82
Polygonum hydropiper	19.4	62.9	148.0	53.8	6
Polygonum hydropiperoides	26.3	36.4	46.5	14.3	2
Polygonum lappathifolium	-	24.8	-	-	1
Potamogeton alpinus	8.3	49.1	225.9	44.8	39
Potamogeton amplifolius	11.8	37.2	250.9	35.1	64
Potamogeton berchtoldii	4.0	63.3	300.6	62.0	73
Potamogeton crispus	19.4	66.2	151.5	44.8	19
Potamogeton diversifolius	-	148.0	-	-	1
Potamogeton epihydrus	0.5	19.6	151.5	31.2	46
Potamogeton fibrillosus	-	130.0	-	-	1
Potamogeton filiformis	19.4	98.9	161.0	46.4	14
Potamogeton foliosus	4.6	65.1	151.5	46.5	13
Potamogeton friesii	20.6	83.7	300.6	68.9	30
Potamogeton gramineus	0.5	69.7	476.8	75.0	117
Potamogeton illinoensis	30.4	102.7	192.1	54.1	13
Potamogeton natans	3.9	66.4	476.8	72.6	106
Potamogeton nodosus	5.0	91.4	300.6	77.4	16
Potamogeton obtusifolius	14.4	44.5	144.0	42.0	8
Potamogeton pectinatus	14.3	140.8	2109.7	226.3	118
Potamogeton praelongus	10.5	61.3	300.6	52.2	67
Potamogeton pusillus	16.5	81.7	191.5	68.9	7
Potamogeton richardsonii	5.9	87.6	300.6	60.4	118
Potamogeton robbinsii	5.9	30.7	120.0	22.2	41
Potamogeton strictifolius	37.6	84.3	120.7	42.5	3
Potamogeton vaginatus	43.7	148.6	418.0	99.0	18
Potamogeton zosteriformis	19.4	89.7	300.6	63.7	51
Potentilla palustris	0.5	56.8	451.5	70.7	80
Ranunculus aquatilis	0.5	59.3	476.0	62.6	139
Ranunculus cymbalaria	120.7	1021.5	4500.0	1944.8	5
Ranunculus flabellaris	16.6	70.3	212.0	68.2	7
Ranunculus flammula	2.8	39.6	250.9	41.9	58
Ranunculus gmelinii	15.4	119.0	300.6	83.4	12
Ranunculus hyperboreus	-	63.2	-	-	1
Ranunculus sceleratus	20.9	146.8	287.0	95.4	6
Riccia fluitans	5.9	56.7	112.8	52.6	5

continued

Alkalinity Data

Species	min. alk.	mean alk.	max. alk.	Std. dev.	N
Ricciocarpus natans	30.4	72.8	112.8	37.1	5
Rorippa nasturtium-aquaticum	20.9	109.8	451.5	122.8	11
Ruppia maritima	12.6	120.8	250.9	77.2	7
Scirpus americanus	51.9	1117.1	4500.0	1916.9	5
Scirpus fluviatilis	-	112.8	-	-	1
Scirpus lacustris	4.8	142.2	2109.7	248.7	104
Scirpus subterminalis	2.5	22.7	151.5	32.2	30
Sium sauve	5.9	56.9	300.6	53.8	38
Sparganium emersum	3.9	45.2	300.6	50.9	76
Sparganium eurycarpum	30.4	96.5	300.6	77.3	10
Sparganium minimum	5.0	54.5	225.9	63.0	19
Spirodela polyrhiza	21.7	79.3	300.6	62.1	21
Subularia aquatica	5.9	30.3	120.0	33.2	11
Tillaea aquatica	4.0	24.7	63.2	20.1	7
Typha latifolia	0.5	78.0	476.8	84.5	109
Utricularia gibba	3.9	27.7	58.1	20.2	5
Utricularia intermedia	3.5	42.5	226.0	61.6	24
Utricularia minor	2.5	57.3	251.0	78.0	21
Utricularia vulgaris	0.5	83.1	476.8	88.8	121
Vallisneria americana	5.9	52.2	130.0	38.8	7
Veronica americana	19.4	82.6	300.6	78.2	11
Veronica anagallis-aquatica	-	36.4	-	-	1
Veronica scutellata	16.4	35.5	63.2	18.8	8
Zannichellia palustris	5.9	106.6	300.6	97.2	15
Genera					
Alisma	5.9	94.1	300.6	92.1	21
Callitriche	1.4	43.0	191.5	41.4	71
Carex	3.3	44.7	166.0	46.2	17
Ceratophyllum	4.0	81.6	300.6	67.5	55
Chara	5.9	97.7	575.0	86.8	119
Eleocharis	4.6	73.0	300.6	66.2	85
Elodea	5.9	45.8	226.0	41.5	55
Equisetum	3.3	64.7	300.6	61.3	110
Glyceria	8.7	12.7	16.2	5.6	2
Isoetes	0.5	23.8	120.0	19.7	59
Lemna	16.4	99.7	476.8	87.3	60
Limosella	5.9	18.0	27.5	9.5	4
Mimulus	8.6	68.0	300.6	84.3	10
Myosotis	14.4	73.0	451.5	94.4	28
Myriophyllum	4.1	102.8	626.0	100.3	163
Nitella	5.9	38.4	151.5	34.3	27
Nuphar	0.5	53.6	289.0	59.2	184
Nymphaea	11.3	49.7	210.2	49.3	25
Polygonum	11.8	123.3	626.0	112.1	83

continued

Alkalinity Data

Genera	min. alk.	mean alk.	max. alk.	Std. dev.	N
Potamogeton	0.5	87.3	2109.7	157.0	302
Ranunculus	0.5	90.3	4500.0	357.0	160
Sagittaria	2.5	64.4	300.6	60.4	41
Scirpus	2.5	164.4	4500.0	446.9	132
Sparganium	1.7	58.0	300.6	61.7	142
Utricularia	0.5	83.6	476.8	89.6	136
Veronica	8.7	60.7	300.6	63.1	20

26. Kadono, Y. 1980. Photosynthetic Carbon Sources in Some Potamogeton Species. Bot. Mag. Tokyo. 93:185-194.

The ability of several species of Potamogeton leaves to use bicarbonate for photosynthesis was assayed in acid and alkaline conditions. The pH ranges over which the species were able to achieve a positive net photosynthesis rate (over 4-5 mg O_2/gdw/hr. or 4-5% relative) are given in the list below.

Species	natural waters	laboratory	best range
Potamogeton crispus	5.4 - 8.9	4.0 - 10.0	4.0 - 6.5
Potamogeton fryeri	5.4 - 7.0	3.8 - 8.5	3.8 - 6.2
Potamogeton oxyphyllus	5.4 - 7.7	4.0 - 8.8	4.0 - 7.7
potamogeton maackianus	5.4 - 8.7		6.2 - 7.0

The best range values are extracted from Figures 1,2 and 4; the natural waters range from Figure 4 and the laboratory range from Figures 1 and 2 and table 2.

27. Hicks, L.F. 1932. Ranges of pH - tolerance of the Lemnaceae. Ohio J. Sci. 32:237-244.

The frequency of finding Lemnaceae in Ohio waters of various pH values was plotted for the 7 species studied: Spirodela polyrhiza, Lemna trisulca, Lemna minor, Lemna cyclostasa, Wolffia columbiana, Wolffia punctata and Wolffiella floridana.

The table below gives the pH ranges of these species under 3 different cultural conditions: A - plants growing wild in natural waters of Ohio, B - plants grown in greenhouse culture in tap or pond water to which variou types of organic material had been added; C - plants growing in buffered inorganic salt solutions. Column D is a composite giving the extreme range found under any culture condition. These pH values are the extremes for survival or ccurrence but growth is poor or occurrence rare at these extremes. Best growth and most occurrences are found in the range about 0.5 pH in from the extremes.

SPECIES	A - Wild	B - Culture	C - Buffer	D - Composite
Spirodela polyrhiza	5.9-7.9	5.8-7.9	5.5-8.0	5.5-8.0
Lemna trisulca	4.9-7.3	4.6-7.5	5.5-7.5	4.6-7.5
Lemna minor	4.4-7.9	4.5-7.8	4.5-7.5	4.4-7.9
Lemna cyclostasa	5.9-7.8	5.2-7.6	5.5-7.5	4.4-7.8
Wolffia columbiana	5.9-7.8	5.8-7.9	6.0-8.5	5.8-8.5
Wolffia puctata	6.0-7.0	6.0-7.7	6.0-8.5	6.0-8.5
Wolffia floridana	4.8-6.8	4.8-6.8	5.0-6.5	4.8-6.8

The table below gives the pH distribution frequency for the Lemnaceae species.

	Number of Occurrences within the given pH range.							
Species	5.0 to 5.4	5.4 to 5.8	5.8 to 6.1	6.1 to 6.4	6.4 to 6.7	6.7 to 7.0	7.0 to 7.3	7.3 to 7.6
Spirodela polyrhiza			4	11	36	39	46	10
Lemna trisulca		8	5	28	35	7	2	
Lemna minor	6	14	9	46	51	28	16	10
Lemna cyclostasa			2	6	4	1		
Wolffia columbiana			5	14	23	21	12	10
Wolffia punctata				2	10	11	8	10
Wolffia floridana	6	5	5	6				

28. Tag El Seed, M. 1968. Effect of pH on the Nature of Competition Between Eichhornia crassipes and Pistia stratiotes. J. Aquat. Plant Manage. 16:53-57.

The competition between Eichhornia and Pistia was studied at various initial proportions of the two species and at 3 pH's, 4, 7 and 9 in culture solution. The pH was adjusted daily. Eichhornia outcompetes Pistia, to the point of elimination at pH 4. Both species grow well at all the pH's.

29. Sharma, B.M. 1984. Ecophysiological Studies on Water Lettuce in a Polluted Lake. J. Aquat. Plant Manage. 22:17-21.

Among other parameters studied, the pH was measured at 3 sites in Oba Lake, Nigeria, from Nov. to Apr. The pH's ranged from 6.8 to 7.6 and peaked at all sites in Jan., the month with the highest temperature. Pistia stratiotes L. grew well at all these pH's. Other species present in the Pistia community included Alternanthera sessilis (L.) R. Br. ex. Roth, Ageratum conyzoides L., Cyperus difformis L., Cyperus tuberosus Rottb. Briton, Echinochloa pyramidalis (Lam.) Hitch and Chase, Fuirena umbellata Rottb., Floscopa africana (C.B.U.) Brenan, Ludwigia leptocarpa Vahl., Marsilea quadrifolia L., Mariscus alternifolius Vahl., Nymphaea lotus L., Pentodon pentandrus (Schum & Thonn.) Vatke, Polygonum salicifolium Brouss, Rynchospora corymbosa (L.) Britton, Salvinia nymphellula Desv. and Torulinium odoratum (L.) Hopper.

30. Toivonen, H. and T. Lappalainen. 1980. Ecology and Production of Aquatic Macrophytes in the Oligotrophic, Mesohumic Lake Suomunjarvi, Eastern Finland. Ann. Bot. Fennici 17:69-85.

The aquatic vegetation of Lake Suomunjarvi in Finland was studied and quantified using belt transects. The pH of the lake was 6.7 with a standard deviation of 0.04 based on 15 samples in the central basin at 1 meter depth. Conductivity was 17.3 ± 0.16.

The species found growing under these conditions included: Fontinalis antipyretica, Fontinalis hypnoides, Drepanocladus trichophyllus, Juncus bulbosus, Phragmites australis, Equisetum fluviatile, Schoenoplectis lacustris, Carex rostrata, Carex lasiocarpa, Eleocharis palustris, Nuphar lutea, Myriophyllum alterniflorium, Isoetes lacustris, Eleocharis acicularis, Ranunculus reptans, Carex elata, Subularia aquatica, Sparganium angustifolium, Potamogeton berchtoldii, Lobelia dortmanna, Potamogeton natans, Lysimachia thyrsiflora, Callitriche palustris, Sparganium friesii, Nuphar pumila, Alisma plantago-aquatica, Sparganium emersum, Isoetes echinospora, Nymphaea alba, Nymphaea candida, Nymphaea tetragona, Potamogeton gramineus, Hippuris vulgaris, Utricularia intermedia, Drepanocladus exannulatus, Calliergon megalophyllum, and Scorpidium scorpioides.

31. Hillman, W.S. 1961. The Lemnaceae, or Duckweeds. A Review of the Descriptive and Experimental Literature. The Botanical Review. 27:221-287.

Some of the experimental work reviewed involved testing the effects of various growth regulators at various pH's. Lemna minor controls, grown in culture, grew well at pH's of 4.6 - 6.1 and 4.2 - 6.2 in several experiments.

32. Hongve, D. 1975. The Littoral vegetation of Nordhytjernet, a small lake in South-east Norway. Norw. J. Bot. 22:83-97.

Plant association studies were carried out in this lake. The pH records for the lake indicate that pH values were about 7 throughout the entire lake all year. In the summer this increased to more than 8 in the trophogenic stratum, with 9.3 being the recorded maximum. Species of aquatics found in the lake include Carex rostrata, Equisetum fluviatile, Phragmites communis, Scirpus lacustris, Polygonum amphibium, Nuphar lutea, Nymphaea alba, Potamogeton alpinus, Potamogeton lucens, Potamogeton obtusifolius, Chara aspera, Potamogeton perfoliatus, Potamogeton pusillus, *Lemna minor*, *Ceratophyllum demersum*, *Utricularia vulgaris*, *Nitella opaca*, *Chara globularia*, *Fontinalis antipyretica*, *Rhynchostegium riparoides*, *Alopecuris aequalis*, *Caltha palustris*, *Lysimachia thyrsiflora*, *Ranunculus repens*, *Scirpus acicularis*, *Scirpus palustris*, *Veronica scutellata*, and *Drepanocladus uncinatus*.

33. Langangen, A. 1974. Ecology and distribution of Norwegian Charophytes. Norw. J. Bot. 21:31-52.

Surveys of 85 lakes in Norway for *Charophytes* was carried out and several chemical parameters of the lakes were also noted, including pH. The pH range found for the following species was presented in graphical form and has been extracted and presented in the tabular form below.

SPECIES	pH range
Chara rudis	7.6 - 8.5
Chara braunii Gmelin	6.6 - 8.6
Chara canescens Desv. & Locs	8.0 - 8.9
Chara aculeolata Kutzing (*C. polyacantha* A. Br.)	7.7 - 8.4
Chara contraria A. Br.	7.7 - 8.4
Chara vulgaris L.	7.4 - 8.5
Chara hispida L.	8.2 - 8.5
Chara tomentosa L.	7.7 - 8.2
Chara aspera Detharding	7.0 - 8.5
Chara strigosa A. Br.	7.3 - 8.5
Chara globularia Thuillier (*C. fragilis* Desv.)	7.0 - 8.5
Nitella opaca Agardh	6.6 - 8.4
Nitella confervaceae (Breb) A. Br. (*N. batrochosperma*) (Reich.) A. Br.	6.6 - 8.0
Nitella gracilis (Smith) Agardh	6.9 - 7.1
Nitella mucronata (A. Br.) Miquel	8.2 - 8.5
Nitella flexilis (L.) Agardh	6.6 - 7.2
Tolypella nidifica (Muller) A. Br.	8.0 - 8.6
Lamprothamnium papulosus (Wallroth) J. Groves	8.0 - 8.8

34. Okland, K.A. 1974. Macrovegetation and Ecological Factors in two Norwegian Lakes. Norw. J. Bot. 21:137-159.

Two lakes in south Norway, Sukkevatn and Grennesvatn, were surveyed for vegetation, morphometry and chemistry. They are shallow, lowland lakes, moderately eutrophic, slightly acidic and moderatelyi rich in lime. Sukkevatn had a pH of 6.0 - 7.1 at the surface between May and October; Grennesvatn had a pH of 5.9 - 6.8 at the surface between May and October. The table below indicates which species of aquatic plants were found in each of the lakes.

Species	Sukkevatn (6.0-7.1)	Grennesvatn (5.9-6.8)
Sparganium ramosum	x	x
Lemna minor	x	
Bidens tripartita	x	x
Alisma plantago-aquatica	x	x
Glyceria fluitans	x	
Equisetum fluviatile	x	x
Carex rostrata	x	x
Carex lasiocarpa	x	
Lysimachia thyrsiflora	x	x
Lythrum salicaria	x	x
Menyanthes trifoliata	x	x
Scirpus lacustris	x	x
Phagmites communis	x	x
Nuphar lutea	x	x
Juncus bulbosus	x	x
Myriophyllum alterniflorum	x	x
Hippuris vulgaris	x	x
Sparganium angustifolium		x
Sparganium minimum	x	
Potamogeton natans	x	x
Nymphaea alba		x
Callitriche polymorpha	x	x
Nitella		x
Potamogeton perfoliatus		x
Potamogeton praelongus		x

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Species	Sukkavatn (6.0-7.1)	Grennesvatn (5.9-6.8)
Utricularia vulgaris		x
Utricularia minor		x
Ranunculus reptans		x
Subularia aquatica		x
Crassula aquatica		x
Limosella aquatica		x
Scirpus palustris		x
Scirpus mamillatus	x	x
Carex vesicaria	x	x
Polygonum hydropiper	x	x
Ranunculus flammula	x	
Veronica scutellata		x
Lysimachia vulgaris	x	x
Lycopus europaeus		x

35. Hinneri, S. 1976. On the Ecology and Phenotypic Plasticity of Vascular Hydrophytes in a Sulphate-rich, Acidotrophic Freshwater Reservoir, S.W. Coast of Finland. Ann. Bot. Fennici 13:97-105.

The freshwater reservoir of Uusikaupunki on the south west coast of Finland was cut off from the sea in 1965 by an embankment between the islands in a chain across the mouth of the sound, the freshwater drainage arises in gyttja clay deposits and is very rich in sulphates and acidic. Early rains, after the summer dry season, may cause the pH of some tributaries to drop to 3.5 and reduce the alkalinity of the reservoir to zero. No bicarbonates are then present and plants dependent on HCO_3^-, rather than CO_2, for photosynthesis can not survive. The renewal time for the reservoir is 18 months. The pH took about 9 years to drop from the original 7.4 to the new value of 4.8. Most of the drop occurred in the 4 year period 67 - 70 when the pH dropped from 7.0 to 5.0.

Plants found prior to the isolation of the reservoir, when the water was brackish and around pH 7.4, included *Myriophyllum spicatum* L., *Najas marina* L., *Potamogeton filiformis* Pers., *Potamogeton panormitanus* Biv., *Potamogeton pectinatus* L., *Ruppia maritima* L., *Zannichellia palustris* L., *Potamogeton perfoliatus* L., *Chara aspera* Willd. and *Chara tomentosa* L. These plants all disappeared after the pH dropped and HCO_3^- reserves were depleted.

Plants presently growing, at pH's around 4.8 (4.6-5.1), include Juncus bulbosus L., Hippuris vulgaris L., Sparganium emersum Rehm., Sparganium minimum Walls., Schoenoplectus lacustris (L.) Palla, Callitriche palustris L., Phagmites australis (Cav.) Trin, Schoenoplectis tabernaemontani (C.C. Gmel) Palla. and Sagittaria sagittifolia L.

Some bays are becoming eutrophic due to nutrient rich runoff. In these areas the pH is highest and the water becomes oxygen deficient during the growing season liberating PO_4 from the sediments, and precipitating manganese. These bays contain Nuphar lutea (L.) Sm., Nymphaea candida K. Presl., Potamogeton natans L., Sagittaria sagittifolia L., Phragmites australis (Cov.) Trin., Sparganium erectum L., Typha angustifolia L., Typha latifolia L., Myriophyllum verticillatum L., Utricularia intermedia Hayne, Utricularia minor L., and Utricularia vulgaris L.

Schoenplectis tabernaemontani is present as relict populations; they were more common prior to reservoir formation.

36. Kansanen, A., and R. Niemi. 1974. On the Production Ecology of Isoetids, especially Isoetes lacustris and Lobelia dortmanna, in Lake Paajarvi, Southern Finland. Ann. Bot. Fennici 11:178-187.

The horizontal distribution of the biomass and production of 5 isoetids, Isoetes lacustris L., Lobelia dortmanmna L., Eleocharis acicularis (L.) R. & S., Ranunculus reptans L. and Subularia aquatica L. was studied on three bottom types. The study took place in Lake Paajarvi, a dysoligotrophic lake in Finland. No pH data was given in this paper but such data was presented in another paper in this series of studies: Ruuhijarvi, R. 1974. A General description of the Oligotrophic Lake Paajarvi, southern Finland, and the Ecological Studies on it. Ann. Bot. Fennici 11:95-104. The mean pH's reported in the surface waters during the ice free period were between 6.9 and 7.1. The means were based on very many samples in the period 1971 to 1973.

37. Merilainen, J. and H. Toivonen. 1979. Lake Keskimmainen, Dynamics of Vegetation in a Small Shallow Lake. Ann. Bot. Fennici 16:123-139.

The aquatic vegetation in the small, mesotrophic Lake Keskimmainen in Finland was studied and mapped. Short and long-term changes are noted. Muskrats are apparently responsible for invasion by *Typha* and reduction in *Phragmites* and *Schoenoplectus*. The summer 1972 pH was 7.4, up from 6.8 under the ice in winter. The species present in the lake include *Carex rostrata*, *Carex vesicaria*, *Carex elata*, *Equisetum fluviatile*, *Phragmites australis*, *Glyceria fluitans*, *Schoenoplectus lacustris*, *Eleocharis mamillata*, *Typha latifolia*, *Cicuta virosa*, *Alisma plantago-aquatica*, *Iris pseudacorus*, *Hippuris vulgaris*, *Lysimachia thyrsifloria*, *Bidens spp.*, *Nymphaea candida*, *Nymphaea tetragona*, *Nuphar lutea*, *Nuphar pumila*, *Potamogeton natans*, *Sagittaria natans*, *Sparganium emersum*, *Sparganium friesii*, *Potamogeton alpinus*, *Potamogeton perfoliatus*, *Potamogeton praelongus*, *Potamogeton berchtoldii*, *Potamogeton compressus*, *Potamogeton obtusifolius*, *Elodea canadensis*, *Sparganium minimum*, *Myriophyllum verticillatum*, *Myriophyllum alterniflorum*, *Ranunculus peltatus*, *Isoetes echinospora*, *Eleocharis acicularis*, *Ranunculus reptans*, *Lemna minor*, *Riccia fluitans*, *Ricciocarpus natans*, *Utricularia vulgaris*, *Utricularia minor*, *Calliergon megalophyllum*, *Drepanocladus aduncus*, *Drepanocladus capillifolius*, *Drepanocladus tenuinervis*, *Drepanocladus trichophyllos*, *Drepanocladus tundrae*, *Fontinalis antipyretica*, *Menyanthes trifoliata*, *Potentilla palustris*, *Galium palustre*, *Lycopus europaeus*, *Carex canescens*, *Calla palustris*, *Lythrum salicaria*, *Ranunculus sceleratus*, *Rorippa palustris*, *Epilobium palustre*, *Agrostis canina*, *Alopecuris aequalis*, *Poa annua*, *Polygonum* spp., *Nitella sp*.

38. Moller, R.E. 1978. Seasonal Changes in Biomass, Tissue Chemistry, and Net Production of the Evergreen Hydrophyte Lobelia dortmanna. Can. J. Bot. 56:1425-1433.

It is hypothesized that the prevalence of rosette growth forms in softwater lakes is an adaptation to nutrient paucity. There is a shorter distance for nutrient transport from the roots in the sediment (where most of the nutrients occur), less total biomass to sustain, less chance of physical or grazing loss of nutrients and in plants like Lobelia dortmanna conservation of nutrients by overwintering with 60% of the summer biomass.

39. Ruuhijarvi, R. 1974. A General Description of the Oligotrophic Lake Paajarvi, Southern Finland and the Ecological Studies on it. Ann. Bot. Fennicii 11:95-104.

The lake is introduced and much basic watershed and limnological data is given as an introduction to further studies. A pH range of 6.9-7.1 can be extracted from Table 3, for the ice-free periods in the littoral zone. Figure 3 gives the vegetation zonation in the lake by depth and lists the following species: Carex rostrata, Typha latifolia, Equisetum fluviatile, Phragmites communis, Potamogeton natans, Nymphaea candida, Sparganium friesii, Ranunculus peltatus, Myriophyllum alterniflorum, Potamogeton perfoliatus, Isoetes lacustris, Lobelia dortmanna, Subularia aquatica, Ranunculus reptans, and Eleocharis acicularis.

40. Merilainen, J. 1970. On the Limnology of the Meromictic Lake Valkiajarvi, in the Finnish Lake District. Ann. Bot. Fennici 8:29-51.

The lake is introduced and basic watershed, morphometry and limnology is discussed. A list of aquatic plants and their abundance values and depth limits is given as well as a table of pH profiles. Plants found include

Sparganium simplex, *Calla palustris*, *Phragmites communis*, *Carex lasiocarpa*, *Potentilla palustris*, *Menyanthes trifoliata*, *Sparganium friesii*, *Sparganium angustifolium*, *Nymphaea alba*, *Nuphar luteum*, *Callitriche polymorpha*, *Potamogeton pusillus*, *Isoetes lacustris*, *Scorpidium scorpioides*, *Drepanocladus exannulatus*, *Amblystegium riparium*, *Fontinalis hypnoides*, *Sphagnum riparium* and *Sphagnum parvifolium*. The pH profiles showed pH's of 5.8 to 6.8 recorded within the range of depths at which the plants grew.

41. Uotila, P. 1971. Distribution and Ecological Features of Hydrophytes in the Polluted Lake Vanajavesi, S. Finland. Ann. Bot. Fennici 8:257-295.

The distribution of aquatic plants in the polluted Lake Vanajavesi was studied and compared with earlier known distribution patterns. pH measurements at 13 sites over 4 years give a range of 6.2 to 7.3 for the lake. The species found included *Equisetum fluviatile*, *Sparganium emersum*, *Lemna minor*, *Potamogeton natans*, *Potamogeton gramineus*, *Potamogeton perfoliatus*, *Butomus umbellatus*, *Hydrocharis morsus-ranae*, *Alisma plantago-aquatica*, *Sagittaria sagittifolia*, *Phragmites australis*, *Glyceria maxima*, *Eleocharis palustris*, *Carex acuta*, *Polygonum amphibium*, *Nuphar lutea*, *Cicuta virosa*, *Spirodela polyrhiza*, *Schoenoplectus lacustris*, *Nymphaea candida*, *Ceratophyllum demersum*, *Ranunculus lingua*, *Typha latifolia*, *Calla palustris*, *Utricularia vulgaris*, *Riccia fluitans*, *Ricciocarpus natans*, *Sparganium erectum*, *Potamogeton obtusifolius*, *Ranunculus peltatus*, *Isoetes setacea*, *Potamogeton berchtoldii*, *Elodea canadensis*, *Stratiotes aloides*, *Eleocharis acicularis*, *Subularia aquatica*, *Elatine hydropiper*, *Elatine triandra*, *Limosella aquatica*, *Drepanocladus exannalatus*, *Nitella wahlbergiana*, *Carex vesicaria*, *Carex elata*, *Myriophyllum verticillatum*, *Rorippa amphibia*, *Potentilla palustris*, *Calliergon megalophyllum*, *Lysimachia thyrsiflora*, *Typha augustifolia*, *Sparganium minimum*, *Sparganium friesii*, *Potamogeton alpinus*, *Iris pseudacorus*, *Alopecuris aequalis*, *Rumex hydrolapathum*, *Ranunculus reptanss*, *Callitriche palustris* (*C. verna*), *Callitriche cophocarpa* (*C. polymorpha*), *Peplis portula*, *Hippuris vulgaris*, *Utricularia* minor, Utricularia intermedia, Fontinalis antipyretica, Fontinalis hypnoides, Drepanocladus aduncus, Drepanopcladus tenuinervis, (D sendtneri), Hygrohypnum ochraceum, Hygroamblystegium (Amblystegium fluviatile), Lepidodictyum riparium (Amblystegium riparium).

42. Filbin, G.J. and R.A. Hough. 1985. Photosynthesis, Photorespiration, and Productivity in Lemna minor L. Limnol. Oceanogr. 30(2):322-334.

Lemna minor productivity was determined in situ in Shoe Lake, alkalinity 3.02-3.88 meq/L and pH around 8, and in the laboratory at pH 6.8 and 8.2.

43. Light, J. J. 1975. Clear Lakes and Aquatic Bryophytes in the Mountains of Scotland. J. Ecol. 63:937-943.

Observations were made in 16 Lochs but in only 4 of these were pH measurements reported. Table 1 below gives the pH ranges reported and other parameters measured for these 4 Lochs. Table 2 gives the species found in these 4 Lochs, no Bryophytes were reported.

TABLE 1

Loch	pH	Conductivity	Secchi (m)	Max. depth (M)	Altitude (M)
Dubh	4.5-5.9(11)	8.6-14.4(11)	7-10(8)	19	640
Kander	5.8-6.5(2)	15.2-16.3(2)	-	18	660
Muick	5.2-6.4(11)	12.8-15.5(11)	5.5-6.5(6)	78	400
Lochnagar	4.5-5.7(11)	12.9-15.0(11)	10-14(4)	26	780

The numbers in ( ) are the numbers of measurements made.

TABLE 2

Lochs (depth range M)

Species	Dubh	Kander	Muick	Lochnagar
Isoetes lacustris	X (1-6)		X (0.5-3)	X (1-6)
Juncus bulbosus	X (1-6)			X (1-6)
Littorella uniflora			X (0.5-3)	
Potamogeton natans			X (2-6)	
Callitriche intermedia		X (1-2)		

44. Gorham, E. and A. G. Gordon. 1963. Some Effects of Smelter Pollution Upon Aquatic Vegetation Near Sudbury, Ontario. Can. Journ. Bot. 41:371-378.

Surveys of aquatic vegetation were made in 29 lakes and ponds near Sudbury. These waters are subject to heavy metal, acidity and sulphur pollution from nearby smelters. The number of species found in a lake decreased with increasing sulphate, though none of the sulphate levels were high enough to be intrinsically toxic. The sulphate levels decreased with increasing distance from the smelters and was an index of pollution. The most likely cause of species paucity was heavy metal pollution under the acidic conditions, primarily copper and nickel, but also possibly iron and manganese. Table 1 gives the number of aquatic species found, water chemistry and distance to the nearest smelter. Table 2 gives the distribution of the aquatic plants in the 29 lakes. The lakes are arranged in order of increasing distance from a smelter. Table 3 gives the species and their pH ranges.

TABLE 1

Lake	Miles to Smelter	SO$_4$ (mg/L)	Ca (mg/L)	pH	# of Species
8	0.9	132.08	14.03	3.3	1
12	1.2	71.08	11.02	3.6	0
53	1.2	74.93	11.62	4.1	3
11	1.5	65.32	7.82	3.5	4
54	1.8	55.71	10.02	4.2	3
65	1.8	90.30	20.84	6.1	2
14	2.3	27.86	4.21	3.9	2
56	2.5	36.98	9.82	6.3	4
4	2.8	48.51	12.83	4.3	4
15	3.1	30.26	5.41	4.1	4
69	3.2	86.45	19.44	6.4	5
21	3.5	53.31	11.22	4.2	8
17	4.0	28.82	19.64	7.9	7
22	4.2	34.10	6.81	4.3	5
75	6.9	23.53	5.41	5.6	4
23	7.0	30.26	9.62	7.0	11
33	7.4	22.09	5.61	6.6	8
24	10.6	24.50	6.21	6.3	7
25	13.3	22.57	7.41	7.0	17
96	15.6	22.57	5.21	5.6	10
29	16.4	17.29	4.21	4.6	6
26	19.2	11.53	5.41	7.2	11
95	19.4	17.77	3.41	4.4	10
94	19.8	11.53	6.61	6.0	17
27	23.4	13.93	6.81	7.4	10
28	24.2	18.73	8.22	7.4	24
103	31	12.01	5.01	6.8	18
105	33	12.97	5.61	6.9	1
104	34	13.93	5.01	6.4	18

TABLE 2

SPECIES	8	12	53	11	54	65	14	56	4	15	69	21	17	22	75	23	33	24	25	96	29	26	95	94	27	28	103	105	104
Leptodictyum riparium	X		X		X				X			X																	
Eleocharis acicularis			X		X	X	X			X		X	X	X		X		X				X				X			
Polytrichum commune					X																								
Juncus pelocarpus								X									X	X	X				X		X	X	X		
Sagittaria sp. or spp.								X				X		X	X	X	X	X	X	X			X	X	X	X	X		X
Eriocaulon septangulare								X					X	X	X	X	X	X	X	X			X	X	X	X	X		X
Cladopodiella fluitans									X			X																	
Isoetes muricata										X		X	X			X				X			X	X					X
Glyceria borealis											X																		
Polygonum amphibium											X		X																
Potamogeton gramineus													X												X	X			
Nymphaea odorata														X	X	X	X		X			X	X			X	X		X
Drepanocladus fluitans																X					X			X					
Lysimachia terrestris																X						X				X	X		
Potamogeton pusillus																X			X										X
Utricularia gibba																X													
Sparganium fluctuans																	X		X			X							X
Lobelia dortmanna																		X	X	X				X	X	X	X		X
Isoetes riparia																		X	X					X	X	X	X		X
Myriophyllum tenellum																		X	X					X		X			X
Nuphar Sp. or Spp.																			X	X	X	X	X			X	X	X	X
Elatine minima																			X										
Utricularia intermedia																				X							X		
Utricularia purpurea																				X				X					
Utricularia vulgaris																					X	X		X		X			X
Eleocharis robbinsii																					X								
Potamogeton epihydrus																						X		X		X	X		X
Fontinalis novae-angliae																						X		X					X
Potamogeton pectinatus																							X						
Utricularia minor																							X						
Potamogeton spirillus																								X		X	X		
Potamogeton robbinsii																									X				
Brasenia schreberi																									X	X			X
Potamogeton amplifolius																										X			
Najas flexilis																										X			
Myriophyllum farwellii																										X	X		
Juncus militaris																											X		
Hippuris vulgaris																													X
Miles from nearest smelter	0	1					2			3				4	5			10		15					20		30		35

TABLE 3

SPECIES	PH RANGE (N)	SPECIES	PH RANGE(N)
Mosses		*Higher Plants (cont'd)*	
Cladopodiella fluitans	4.2-4.3(2)	*Myriophyllum tenellum*	6.0-7.4(5)
Drepanocladus fluitans	4.6-7.0(3)	*Najas flexilis*	7.4 (1)
Fontinalis novae-angliae	6.0-7.2(3	*Nuphar* sp./spp.	4.4-7.4(9)
Lepidodictyum riparium	3.3-4.3(5)	*Nymphaea odorata*	4.3-7.4(10)
Polytrichum commune	4.2 (1)	*Polygonum amphibium*	6.4-7.9(2)
		Potamogeton amplifolius	7.4 (1)
Higher Plants		*Potamogeton epihydrus*	6.0-7.4(5)
Brasenia schreberi	6.4-7.4(3)	*Potamogeton gramineus*	7.4-7.9(3)
Elatine minima	7.0 (1)	*Potamogeton pectinatus*	4.4 (1)
Eleocharis acicularis	3.9-7.9(12)	*Potamogeton pusillus*	6.4-7.0(3)
Eleocharis robbinsii	4.6 (1)	*Potamogeton robbinsii*	7.4 (1)
Eriocaulon septangulare	4.2-7.4(1)	*Potamogeton spirillus*	6.0-7.4(3)
Glyceria borealis	6.4 (1)	*Sagittaria* sp./spp.	4.4-7.4(11)
Hippuris vulgaris	6.4 (1)	*Sparganium fluctuans*	6.4-7.2(4)
Isoetes muricata	4.1-7.9(8)	*Utricularia gibba*	7.0 (1)
Isoetes riparia	6.0-7.4(7)	*Utricularia intermedia*	5.6-6.8(2)
Juncus militaris	6.8 (1)	*Utricularia minor*	4.4 (1)
Juncus pelocarpus	4.4-7.4(8)	*Utricularia purpurea*	5.6-6.0(2)
Lobelia dortmanna	5.6-7.4(8)	*Utricularia vulgaris*	4.6-7.4(5)
Lysimachia terrestris	6.8-7.4(4)		
Myriophyllum farwellii	6.8-7.4(2)		

45. Suominen, J. 1968. Changes in the Aquatic Macroflora of the Polluted Lake Rautavesi, S.W. Finland, Ann. Bot. Fenn. 5:65-81.

A comparison of the species and their distribution in Lake Rautavesi in 1954 and in 1967 is documented. The pH in 1967 was about 6.5 and the species found included:

Ceratophyllum demersun, *Elodea canadensis*, *Myriophyllum verticillatum*, *Potamogeton zosteriformis*, *Hydrocharis morsus-ranae*, *Spirodela polyrrhiza*, *Ricciocarpus natans*, *Riccia fluitans*, *Lemna minor*, *Utricularia vulgaris*, *Potamogeton obtusifolius*, *Butomus umbellatus*, *Typha latifolia*, *Glyceria maxima*, *Nymphaea candida*, *Sparganium simplex*, *Sparganum erectum*, *Potamogeton alpinus*, *Calla palustris*, *Sagittaria sagittifolia*, *Scirpus lacustris*, *Equisetum fluvatile*, *Myriophyllum alterniflorum*, *Ranunculus peltatus*, *Ranunculus lingua* and *Sparganium friesii*.

46. Kurimo, U. 1970. Effect of Pollution on the Aquatic Macroflora of the Varkaus Area, Finnish Lake District. Ann. Bot. Fennici 7:213-254.

The effects of water pollution on aquatic plants in the drainage basin of the Vuoksi River were investigated. The pH's found in the surface waters ranged from 6.0 to 6.9; the plants found included those which benefited from pollution, those which suffered from the pollution and those which were not affected.

Species benefiting by the Pollution

Ceratophyllum demersum, *Stratiotes aloides*, *Myriophyllum verticillatum*, *Utricularia vulgaris*, *Nymphaea candida*, *Alopecuris aequalis*, *Spirodela polyrrhiza*, *Lemna minor*, *Potamogeton natans*, *Nymphaea tetragona*, *Sagittaria natans*, *Sparganium simplex*, *Sagittaria sagittifolia*, *Elodea canadensis*, *Hippuris vulgaris*, *Hydrocharis morsus-ranae*, *Glyceria fluitans*, *Callitriche verna*, *Potamogeton gramineus*, *Typha latifolia* and *Potamogeton perfoliatus*.

All the species listed above up to and including *Potamogeton natans* benefit by all types of pollution, those following *P. natans* benefit by sewage but are harmed by wood-waste pollution.

Species indifferent to pollution

Phragmites communis, *Nuphar luteum*, *Carex acuta* , *Alisma plantago-aquatica*, *Carex vesicaria*, *Polygonum amphibium*, *Iris pseudacorus*, *Sparganium friesii*, *Lysimachia thyrsiflora*, *Scirpus lacustris* and *Carex rostrata*.

Species suffering from the pollution

Ranunculus reptans, *Eleocharis palustris*, *Potamogeton pusillus*, *Utricularia intermedia*, *Isoetes lacustris*, *Ranunculus peltatus*, *Eleocharis acicularis*, *Isoetes echinospora*, *Subularia aquatica*, and *Equisetum fluviatile*. The following species shun contaminated waters completely *Myriophyllum alternifolium*, *Lobelia dortmanna*, *Elatine hydropiper*, *Sparganium angustifolium*, *Potamogeton praelongus* and *Littorella uniflora*.

47. Eloranta, P. 1970. Pollution and Aquatic Flora of Waters by Sulphate Cellulose Factory at Mantta, Finnish Lake District. Ann. Bot. Fennici 7:63-141.

The distribution of aquatic plants in a lake system subject to pollution by low pH effluent (pH 3.1) was mapped and pH measurements of the water in different basins and areas was noted. From (figures 31,35, and 46 to 83) in this report the following pH ranges for aquatic plants could be extracted.

pH 4.2 - 5.3

Hippuris vulgaris
Nymphaea candida
Sparganium minimum
Potamogeton natans
Myriophyllum verticillatum
Utricularia vulgaris
Potamogeton gramineus
Potamogeton pusillus
Utricularia intermedia
Polygonum amphibium
Alisma plantago-aquatica
Nuphar luteum
Equisetum fluviatile
Scirpus lacustris
Eleocharis palustris
Lysimachia thyrsiflora
Phragmites communis
Glyceria fluitans
Sparganium simplex
Iris pseudacorus

pH 4.5
Typha latifolia

pH 4.2 - 4.9

Utricularia minor

pH 4.2 - 6.0
Elodea canadensis

pH 4.2 - 5.8
Ranunculus flammula
Sagittaria sagittifolia
Callitriche verna

pH 4.5 - 5.8
Juncus bulbosus

pH 4.5 - 6.0
Potamogeton perfoliatus
Myriophyllum alterniflorum

pH 4.9 - 5.3
Eleocharis acicularis

pH 5.3
Isoetes echinospora

pH 4.9 - 6.0

Sparganium friesii

pH 5.3 - 5.8
Elatine hydropiper
Elatine triandra

pH 5.3 - 6.0
Ranunculus peltatus
Subularia aquatica
Isoetes lacustris

pH 5.8 - 6.0
Lobelia dortmanna
Littorella uniflora

pH 4.2
Eleocharis mamillata
Potamogeton alpinus
Sparganium erectum
Lemna minor

48. Rothrock, P. E. and R. W. Wagner. 1975. *Eleocharis acicularis* (L.) R. & S. :The Autecology of an Acid Tolerant Sedge. Castanea 279-289.

Eleocharis acicularis forms an extensive green mat on bank and stream bottoms in the appalachian area where acid mine drainage reduces the pH of the water to the pH 3.0 to pH 5.0 range. *E. acicularis* can be very abundant under these conditions and very little else will grow here. The rhizomatous plants grow well in clays and silts but the delicate rhizomes cannot penetrate sand. In the 10 field sites tested the pH of water dropped as low as 2.85 and the pH of the sediment to 4.40. A few poorly developed plants were found at 2 non-acidified sites at pH's of 7.50 and 7.90 but no well developed mats formed above pH 7.1. Sparganium americanum, Dulichium arundinaceum and Juncus acuminatus were found associated with the E. acicularis mats under less severe conditions.

49. Hutchinson, G. E. 1970. The Chemical Ecology of Three Species of Myriophyllum (Angiospermae, Haloragaceae). Limnology and Oceanography 15(1):1-5.

The relationships between pH and calcium and the distribution of Myriophyllum alterniflorum, M. spicatum and M. verticillatum in Sweden were explored. M. spicatum grew in much higher calcium levels and higher pH levels than the other two sympatric species.

Myriophyllum species	pH	Ca (mg/L)
M. alterniflorum	6.0 - 8.1	0.6 - 35.2
M. verticillatum	6.8 - 7.8	4.2 - 35.6
M. spicatum	6.8 - 8.1	2.8 - 47.8

50. Kadono, Y. 1982. Occurrence of Aquatic Macrophytes in relation to pH, Alkalinity, Ca^{++}, Cl^{-} and conductivity. Japanese Journal of Ecology 32:39-44.

A survey of over 700 aquatic sites in Japan was carried out for aquatic plants which were found in 618 of these sites. Sites included lakes, ponds, rivers and irrigation ditches, both fresh and brackish. Emergent plants or helophytes were excluded from the survey. Water sampling and analyses was carried out at 500 of these sites for pH, alkalinity, Ca^{++}, Cl^{-} and conductivity. The pH and alkalinity data are reported in the table below.

	pH				Alkalinity (mg/L)			
Species	Min.	Max.	Median	N	Min.	Max.	Median	N
Myriophyllum ussuriense	6.3	8.5	7.1	23	6.00	34.0	15.0	23
Brasenia schreberi	5.6	8.7	6.8	86	2.50	47.0	15.5	86
Nymphaea tetragona	4.9	8.6	6.9	78	1.50	52.0	16.0	79
Nuphar pumilum	5.3	7.2	6.6	13	2.50	33.5	18.5	13
Utricularia japonica	4.9	8.3	6.8	63	3.00	116	22.0	64
Nymphoides indica	5.9	10.9	7.7	33	7.00	62.5	22.0	34
Myriophyllum verticillatum	5.9	8.7	6.7	20	5.50	96.5	22.5	20
Najas minor	6.6	9.0	7.3	17	10.0	79.5	24.0	17
Trapa natans	6.7	10.0	7.3	15	12.5	59.5	25.0	15
Nuphar japonicum	5.9	9.0	6.8	34	6.00	67.5	25.0	34
Hydrilla verticillata	6.1	9.7	7.4	116	6.00	451	26.0	116
Trapa japonica	5.9	10.2	7.4	167	7.00	28.0	28.0	169
Vallisneria asiatica	6.5	9.7	7.8	41	9.01	59.5	28.5	42
Najas marina	6.6	9.2	7.7	18	10.0	60.0	31.0	18
Elodea nuttallii	6.3	9.4	7.8	49	5.50	79.6	32.0	49
Elodea densa	6.4	9.2	7.3	26	22.0	103	34.0	26
Ceratophyllum demersum	6.1	9.7	7.0	69	9.01	451	34.5	69
Myriophyllum spicatum	6.5	9.6	7.7	60	13.0	145	35.0	60
Spirodela polyrhiza	6.4	9.2	7.6	20	18.0	103	50.5	21
Hydrocharis dubia	6.7	9.2	7.3	22	29.0	153	54.0	22

51. Kadono, Y. 1982. Distribution and Habitat of Japanese Potamogeton. Bot. Mag. Tokyo. 95:63-76.

A survey of over 700 aquatic sites in Japan was carried out for aquatic plants. Only Potamogeton is reported in this paper and it was found in 402 sites which included rivers, streams, creeks, lakes, ponds, marshes, reservoirs, bogs and paddies. Water sampling and analyses were carried out for pH, alkalinity, Ca^{++}, Cl^- and conductivity. The pH and alkalinity data are reported below.

Potamogeton Species	pH			Alkalinity (mg/L)		
	range	median	N	range	median	N
P. fryeri	4.8-9.2	6.4	52	2.00-72.0	9.51	52
P. octandrus	5.7-9.3	6.9	96	3.00-81.0	22.0	96
P. distinctus	6.1-10.9	7.3	71	4.00-83.8	24.0	71
P. natans	5.7-8.9	6.7	33	5.50-112	25.0	33
P. gramineus	6.5-8.6	7.2	22	13.0-96.6	26.5	22
P. maackianus	6.1-9.7	7.5	52	9.01-62.0	27.5	52
P compressus	6.5-8.0	6.9	10	18.5 -116	29.5	10
P. perfoliatus	6.5-9.7	7.5	32	9.01-59.5	30.0	32
P. oxyphyllus	5.3-9.1	7.1	41	5.50-81.0	31.0	41
P. pusillus	6.5-8.9	7.6	21	10.0-96.6	31.0	21
P. malaianus	6.8-9.2	7.9	19	20.5-104	36.0	19
P. crispus	6.3-9.6	7.4	102	13.5-153	40.5	103
P. pectinatus	7.1-8.7	7.5	11	31.0-116	57.0	11
P. alpinus	6.9-8.7	7.1	5	18.5-40.5	31.5	5
P. praelongus	7.1-7.8	7.7	3	13.0-31.0	15.5	3
P. obtusifolius	-	6.5	1	-	52.5	1
P. cristatus	-	6.4	1	-	8.51	1

52. Ball, E. and J. Glucksman. 1980. A Limnological Survey of Lake Dakataua, A large Caldera Lake on West New Britain, Papua, New Guinea, with comparisons to Lake Wisdom, a younger nearby Caldera Lake. Freshwater Biology 10: 73-84.

The surface pH of this Caldera Lake was 7.8 and alkalinity 81 mg/L (as HCO_3). The pH's at various surface stations varied from 7.6 to 8.2 and the alkalinity varied from 78.5 to 83.6 mg/L. The aquatic plants found included Chara sp., Najas tenuifolia, Lemna perpusilla and Pandanus sp.

53. Kaj Sand-Jensen and M. Sondergaard. 1979. Distribution and Quantitative Development of Aquatic Macrophytes in Relation to Sediment Characteristics in Oligotrophic Lake Kalgaard, Denmark. Freshwater Biology 9:1-11.

The surface pH of Lake Kalgaard varies between pH 6.5 and pH 8.2. The species of aquatic plants found and their area of coverage are given in the table below.

Species	Areal Coverage	
	m^2	% of bottom
Phragmites communis L.	779	0.5
Scirpus lacustris L.	580	0.5
P. communis + *S. lacustris*	260	0.2
Carex rostrata With.	270	0.2
Equisetum fluviatile L.	60	0.05
Carex lasiocarpa Ehrh.	60	0.05
Polygonum amphibium L.	3 010	2.5
Potamogeton natans L.	70	0.6
Isoetes lacustris L.	34 800	28.9
Littorella uniflora (L.) Aschers	19 390	16.1
Lobelia dortmana L.	10 900	9.0

54. Crowder, A.A., J.M. Bristow and M.R. King. 1977. The Aquatic Macrophytes of Some Lakes in Southeastern Ontario. Naturaliste Can. 104:457-464.

The pH, specific conductivity and aquatic plant flora of 16 sites in southeastern Ontario were surveyed. The data is recorded in the table below. The names of the coded sites are as follows:

1. Lake of Two Rivers
2. Carson Lake
3. Mazinaw Lake
4. Napanee R. (Colebrook)
5. Sand Lake
6. Varty Lake
7. Opinicon Lake
8. Nigger Head (Kingston Mills)
9. Charleston Lake
10. East Lake
11. Quinte (Trenton)
12. West Lake
13. Loughborough Lake
14. Quinte (Hay Bay Mouth)
15. Mud Lake
16. Landon Bay
17. Quinton (Picton Harbour)
18. Quinte (Adolphus Reach)
19. Lime Lake
20. Simcoe Is. Channel
21. Deadman's Bay

Species	Sites																					Species	
	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Conductivity Range	pH Range
pH	6.3	6.5	6.9	7.1	8.3	7.5	7.7	8.2	8.7	8.5	8.2	8.5	8.5	8.2	8.4	8.5	8.2	8.2	7.5	8.5	8.5		
Specific Conductivity	33	56	57	124	165	169	182	216	220	226	230	240	240	246	260	265	271	294	312	312	316		
Lobelia dortmanna	x	x																				33-56	6.3-6.5
Eriocaulon septangulare	x	x	x																			33-57	6.3-6.9
Myriophyllum tenellum	x	x																				33-56	6.3-6.5
Myriophyllum farwellii	x											x										33-240	6.3-8.5
Utricularia purpurea	x																					33	6.3
Utricularia minor			x				x															57-200	6.9-8.5
Utricularia intermedia	x						x															33-200	6.3-8.5
Potamogeton spirillus			x																			57	6.9
Brasenia schreberi	x						x															33-200	6.3-8.5
Isoetes echinospora	x	x	x				x															33-200	6.3-8.5
Potamogeton epihydrus		x	x				x															56-200	6.5-8.5
Chara braunii	x		x		x		x			x	x	x										33-240	6.3-8.5
Nitella tenuissima	x	x	x				x															33-200	6.3-8.5
Nitella flexilis	x				x		x				x					x						33-265	6.3-8.5
Utricularia vulgaris	x		x	x	x		x					x							x			33-312	6.3-8.5
Nuphar variegatum	x		x	x	x		x		x	x		x						x				33-294	6.3-8.7
Chara globularis	x						x			x		x	x	x								33-246	6.3-8.5
Potamogeton gramineus		x				x	x						x						x			56-312	6.5-8.5
Najas flexilis		x	x		x	x	x	x		x		x	x	x			x	x	x			56-312	6.5-8.5
Nymphaea odorata			x	x	x		x	x	x		x		x			x	x					57-271	6.9-8.7
Potamogeton amplifolius			x	x	x		x					x										57-240	6.9-8.5
Elodea canadensis			x	x	x		x	x	x		x	x	x			x	x	x	x	x	x	57-316	6.9-8.7
Potamogeton richardsonii			x		x		x		x	x	x	x						x		x	x	57-316	6.9-8.7
Potamogeton natans				x	x		x															124-200	7.1-8.5
Myriophyllum heterophyllum				x																		124	7.1
Fontinalis antipyretica				x									x									124-240	7.1-8.5

Continued

Species	Sites																					Species	
	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Conductivity Range	pH Range
pH	6.3	6.5	6.9	7.1	8.3	7.5	7.7	8.2	8.7	8.5	8.2	8.5	8.5	8.2	8.4	8.5	8.2	8.2	7.5	8.5	8.5		
Specific Conductivity	33	56	57	124	165	169	182	216	220	226	230	240	240	246	260	265	271	294	312	312	316		
Potamogeton praelongus				x	x		x					x										124-240	7.1-8.5
Potamogeton perfoliatus				x	x		x															124-200	7.1-8.5
Bidens beckii				x	x		x					x										124-240	7.1-8.5
Potamogeton robbinsii				x	x		x		x			x										124-240	7.1-8.7
Potamogeton illinoensis				x	x	x	x		x				x		x							124-260	7.1-8.7
Ceratophyllum demersum				x	x		x	x	x		x	x				x	x	x		x	x	124-316	7.1-8.7
Potamogeton friesii				x	x	x	x			x			x						x		x	124-316	7.1-8.5
Potamogeton crispus				x	x		x	x								x	x	x			x	124-316	7.1-8.5
Potamogeton pectinatus				x	x	x	x	x	x		x	x	x	x		x	x	x	x	x		123-312	7.1-8.7
Vallisneria americana				x	x		x	x	x		x	x		x	x	x	x	x		x	x	124-316	7.1-8.7
Potamogeton zosteriformis				x	x		x	x	x		x	x	x		x			x			x	124-316	7.1-8.7
Ranunculus aquatilis				x	x		x	x				x	x	x		x	x			x	x	124-316	7.1-8.5
Heteranthera dubia				x	x		x	x	x	x	x		x	x	x			x		x	x	124-316	7.1-8.7
Chara vulgaris					x	x	x		x	x		x							x			165-312	7.5-8.7
Callitriche hermaphroditica					x		x															165-182	7.7-8.5
Tolypella intricata							x		x	x		x										182-240	7.7-8.7
Myriophyllum verticillatum							x						x		x							182-260	7.7-8.5
Zannichellia palustris							x			x		x	x	x							x	182-316	7.7-8.5
Najas quadalupensis					x		x	x	x		x	x		x		x				x	x	165-316	7.7-8.7
Potamogeton pusillus							x	x	x		x	x		x		x	x			x	x	182-316	7.7-8.7
Drepanocladus sp.											x											230	8.2
Potamogeton nodosus										x	x											226-230	8.2-8.5
Polygonum natans								x	x		x											182-230	8.2-8.7

*The minimum values are given for pH and specific conductivity.
The measured ranges are 7.7-8.5 for pH and 182-200 for specific conductivity.

55. Nicholson, S.A. 1981. Changes in Submersed Macrophytes in Chautauqua Lake, 1937-1975. Freshwater Biology 11:523-530.

A comparison is made between the species composition of Chautauqua Lake in 1937 and in 1972/1975 and the alkalinity ranges found in the lake during these two periods.

Species	Species Presence/Abundance	
Year	1937	1972/1975
Alkalinity (mg/L as $CaCO_3$)	38-56	39-68
Potamogeton diversifolius	x	-
Potamogeton epihydrus	x	-
Potamogeton vaseyi	x	-
Potamogeton pectinatus	?	-
Potamogeton amplifolius	xxxx	xx
Potamogeton zosteriformis	xxxx	x
Potamogeton gramineus	xxx	x
Potamogeton praelongus	xxxx	xxx
Potamogeton illinoensis	xx	x
Potamogeton robbinsii	xx	x
Potamogeton crispus	xxxx	xxxx
Potamogeton pusillus	xxxx	xxxx
Potamogeton foliosus	xx	xx
Potamogeton natans	x	x
Potamogeton richardsonii	?	xxxx
Heteranthera dubia	xxxx	xxx
Najas flexilis	xxxx	xxx
Bidens beckii	xx	x
Elodea nuttallii	-	xxxx
Najas guadalupensis	-	xxxx
Ranunculus trichophyllous	-	xxx
Myriophyllum exalbescens	xxx	xxxx
Ceratophyllum demersum	xxxx	xxxx
Elodea canadensis	xxxx	xxxx
Vallisneria americana	xxxx	xxxx
Myriophyllum tenellum	?	xx

? - present but abundance not known; x: rare, xx: infrequent (under 25%) of characteristic habitats); xxx: frequent (25-50% of characteristic habitats); xxxx: common (widespread where suitable); -: not present.

56. Ham, S.F., D.A. Cooling, P.D. Hiley, P.R. McLeish, H.R.A. Scorgie and A.D. Berrie. 1982. Growth and Recession of Aquatic Macrophytes on a Shaded Section of the River Lambourn, England, from 1971 to 1980. Freshwater Biology. 12:1-15.

The patterns of growth and recession were documented for nine years for the dominant species of aquatic plants growing in a section of the Lambourn River. This is a comparison to growth on a nearby unshaded portion of this chalk stream. The pH of this reach varied from 8.4 to 7.0 with a mean of 8.0 and standard deviation of 0.2. The alkalinity varied from 295.2 to 115.1 with a mean of 225.1 and a standard deviation of 20.0. Other water chemistry measurements were also made, including suspended solids, silicon, nitrate, chloride, phosphate, calcium, magnesium, sodium, potassium, sulphate, temperature, discharge and conductivity. The aquatic plants recorded include Berula erecta, Ranunculus penicillatus, Callitriche obtusangula, Callitriche stagnalis, Apium nodiflorum, Elodea canadensis, Epilobium hirsutum, Eupatorium cannabinum, Fontinalis antipyretica, Lythrum salicaria, Mentha aquatica, Myosotis scorpioides, Ranunculus peltatus, Scrophularia auriculata, Sparganium erectum, Veronica beccabunga, Veronica catenata, Rorripa nasturtium-aquaticum.

57. Olsen, S. 1950. Aquatic Plants and Hydrospheric Factors. I. Aquatic Plants in SW Jutland, Denmark. Svensk Botanisk Tidskrift. Bd. 44.H:1-34.

58. Olsen, S. 1950. Aquatic Plants and Hydrospheric Factors. II. The Hydrospheric Types. Svensk Botanisk Tidskrift Bd. 44.H:333-373

The distribution of aquatic plants in 86 Danish lakes and some water chemistry data is presented in these two papers. The data for pH ranges of the aquatic plants is tabulated in the list below and has been extracted from the tables and species-preference descriptions found in these two papers.

Species	pH Ranges
Acorus calamus	7.8-8.9
Agrostis stolonifera	7.7-8.0
Alisma plantago-aquatica	5.4-9.2
Berula erecta	7.7-8.2
Butomus umbellatus	7.0-8.9
Calliergonella cuspidata	7.0-7.4
Callitriche polymorpha	7.0-8.2
Callitriche stagnalis	7.0-8.2
Campylium polygamum	6.0
Carex lasiocarpa	6.4-8.3
Carex rostrata	5.2-8.0
Ceratophyllum demersum	6.4-9.3
Chara fragilis	6.0
Drepanocladus exannulatus	5.2
Drepanocladus fluitans	5.2-5.8
Elodea canadensis	6.0-9.0
Equisetum fluviatile	5.4-9.0
Eriophorum angustifolium	5.8-8.3
Fontinalis antipyretica	5.4-8.9
Glyceria fluitans	5.2-8.3
Glyceria maxima	6.3-8.9
Hippuris vulgaris	7.8
Lemna minor	5.2-9.2
Lemna trisulca	5.4-9.1
Littorella uniflora	5.2-9.0
Lobelia dortmanna	4.1-8.3
Mentha aquatica	6.2-8.4
Menyanthes trifoliata	5.2-9.1

Continued

Species	pH ranges
Myriophyllum alterniflorum	6.2-8.2
Myriophyllum spicatum	6.0-8.9
Myriophyllum verticillatum	7.8-8.0
Nuphar lutea	5.4-9.0
Nymphaea alba	3.4-8.9
Oenanthe aquatica	7.0-8.4
Phragmites communis	5.2-9.1
Polygonum amphibium	3.4-9.0
Potamogeton alpinus	6.4-8.2
Potamogeton crispus	7.0-8.5
Potamogeton gramineus	6.4-8.9
Potamogeton lucens	6.4-8.9
Potamogeton natans	5.2-8.3
Potamogeton obtusifolius	6.4-8.9
Potamogeton panormitanus	8.1-9.2
Potamogeton pectinatus	7.0-8.9
Potamogeton perfoliatus	6.0-8.9
Potentilla palustris	6.9-8.3
Ranunculus circinatus	7.2-8.4
Ranunculus flammula	5.8-8.3
Ranunculus peltatus	7.7-8.2
Ranunculus pseudofluitans	7.2-8.9
Rorippa nasturtium-aquaticum	8.2
Rumex hydrolapathum	8.0-8.9
Sagittaria sagittifolia	7.0-8.4
Scirpus acicularis	6.4-8.3
Scirpus lacustris	6.0-9.1
Scirpus maritimus	7.8-9.2
Scirpus palustris	4.1-9.0
Scirpus tabernaemontani	8.5-8.9
Sium latifolium	7.0-8.4
Solanum dulcamara	7.0-8.9
Sparganium angustifolium	4.1-5.2
Sparganium ramosum	7.0-8.9
Sparganium simplex	7.0-8.9
Sphagnum cuspidatum	4.1-5.2
Sphagnum subsecundum	3.4-5.8
Spirodela polyrhiza	6.2-8.9
Stratiotes aloides	7.0-8.4
Typha latifolia	5.2-8.9
Utricularia minor	8.3
Veronica anagallis-aquatica	7.8
Zannichellia palustris	8.2-8.9

59. Kadono, Y. 1987. Personal Communications: Aquatic Plant Distribution and Water Chemistry in Japan. (Dr. Yasuro Kadono, College of Liberal Arts, Department of Biology, Kobe University, Nada, Kobe 657, Japan.

Data on the distribution of aquatic plants collected in 1980-1983, mostly from East Harima Province, Hyogo Prefecture, is given in the table below. The first six species are from a different data set and represent data from all of Japan collected before 1980. The pH's, alkalinities and conductivities, along with means and the number of samples, are the chemical parameters given.

Species	N	pH Range	pH Mean	Alkalinity mg/L Range	Alkalinity mg/L Mean	Conductivity (µS/cm) Range	Conductivity (µS/cm) Mean
Najas oguraensis	7	6.8-7.7	7.3	12.5-67.5	35.5	56-261	120
Euryale ferox	8	6.8-9.6	7.9	12.5-76.5	46.5	62-380	217
Nymphoides peltata	5	5.9-8.8	7.5	10.5-91.6	41.5	38-640	284
Batrachium nipponicus	6	7.1-8.3	7.5	9.00-40.0	25.5	80-181	141
Utricularia aurea	6	6.4-7.4	6.8	8.00-19.5	14.5	37-84	56
Spirodela oligorhiza	7	7.3-9.4	-	18.0-76.5	-	197-400	-
Utricularia aurea	29	5.7-9.3	7.1	7.50-43.0	21.0	27-212	90
Utricularia australis	37	5.9-8.7	6.9	7.50-63.5	22.5	27-261	83
Utricularia minor	1		6.8		10.0		42
Utricularia exoleta	3	7.2-7.4	7.3	14.0-74.0	38.5	70-368	187
Limnophila sessiliflora	12	6.2-7.8	7.1	14.5-121.1	33.0	61-323	104
Nymphoides indica	90	6.6-8.7	7.4	10.5-66.5	32.0	42-1436	148
Nymphoides peltata	1		7.4		68.5		264
Myriophyllum verticillatum	12	6.6-7.6	7.0	8.51-75.5	38.5	58-235	122
Myriophyllum ussuriense	47	6.3-9.9	7.3	8.00-32.0	20.0	28-180	80
Trapa japonica	227	6.0-10.5	7.5	7.50-117.6	39.5	29-870	159
Trapa incisa	9	7.0-8.1	7.7	13.5-51.5	44.5	83-220	174
Trapa sp.	115	6.2-10.4	7.7	7.00-84.6	44.5	42-1436	204
Ceratophyllum demersum	32	6.0-9.4	7.3	14.5-79.5	39.5	57-368	152
Brasenia schreberi	68	5.7-9.4	7.0	8.00-63.5	21.5	27-392	85
Nuphar subintegerrinum	22	6.1-8.2	7.0	10.0-57.5	22.5	40-189	86
Cabomba caroliniana	4	6.8-7.8	7.2	16.0-57.5	40.0	52-216	147
Nymphaea tetragona	50	5.8-9.4	7.2	7.50-95.1	25.0	27-368	90
Nymphaea sp. (Cult.)	8	6.0-7.7	7.1	9.51-43.5	26.5	28-155	111
Euryale ferox	16	6.5-10.1	7.7	26.0-79.5	52.0	116-392	224
Nelumbo nucifera	47	6.2-9.8	7.4	15.0-135.1	52.0	59-451	204
Monochoria vaginalis	1		6.6		34.5		87
Monochoria korsakowii	1		6.5		48.5		392

Continued

Species	pH			Alkalinity mg/L		Conductivity (µS/cm)	
	N	Range	Mean	Range	Mean	Range	Mean
Eichhornia crassipes	9	5.7-10.6	7.8	17.5-125.6	64.0	59-403	258
Spirodela polyrhiza	46	6.3-10.1	7.4	16.5-125.6	59.5	59-415	237
Lemna minima	3	7.2-7.5	7.4	49.5-74.0	63.5	231-368	286
Lemna paucicostata	34	6.4-9.6	7.5	14.5-77.0	49.5	67-451	194
Lemna minor	6	6.6-9.3	7.7	27.5-135.1	64.0	94-420	287
Lemna valdiviana	3	6.8-7.4	7.1	69.0-125.6	98.1	233-403	322
Wolffia arrhiza	2	6.5-7.2	6.9	74.0-75.0	74.5	283-368	326
Hydrocharis dubia	14	7.2-9.3	7.9	49.0-77.0	62.5	180-415	262
Ottelia alismoides	5	6.9-7.8	7.3	17.5-121.1	65.0	45-368	215
Vallisneria asiatica	27	6.7-9.3	7.5	14.0-53.5	29.0	45-1436	166
Blyxa echinospora	1		7.0		17.5		50
Blyxa japonica	1		7.0		17.5		50
Hydrilla verticillata	103	6.1-9.6	7.4	8.51-79.5	32.0	29-1436	143
Elodea nuttallii	43	6.6-9.4	7.6	13.5-97.6	36.5	66-507	163
Elodea densa	1		8.8		36.0		176
Sagittaria trifolia	5	6.8-8.0	7.3	31.5-61.0	47.5	96-205	167
Alisma canaliculatum	8	6.6-7.8	7.3	14.0-95.1	31.0	70-291	113
Caldesia reniformis	10	6.6-8.9	7.2	11.5-77.5	39.0	57-368	143
Najas marina	10	6.9-8.9	7.6	13.5-50.5	27.5	66-193	115
Najas minor	11	6.7-8.2	7.4	13.0-75.0	35.5	63-291	130
Najas graminea	16	6.4-9.2	7.5	11.5-95.0	29.5	42-291	105
Najas oguraensis	28	6.5-9.4	7.6	17.5-74.0	38.5	45-1436	214
Najas foevolata	3	6.9-7.8	7.5	27.5-95.1	51.5	95-291	163
Najas japonica	1		7.8		31.5		103
Potamogeton distinctus	53	5.7-9.3	7.4	7.50-95.1	30.5	45-320	112
Potamogeton fryeri	7	6.4-7.0	6.7	12.0-34.5	20.0	31-89	67
Potamogeton octandrus	70	6.3-9.6	7.4	9.01-63.5	25.5	27-1436	116
Potamogeton cristatus	4	6.5-7.8	7.0	16.0-95.1	45.5	64-392	204
Potamogeton oxyphyllus	1		9.4		17.5		57
Potamogeton crispus	1		8.4		42.0		185
Potamogeton maackianus	9	7.2-9.4	7.9	24.0-58.0	36.0	107-283	176
Potamogeton spp.	14	6.2-9.3	7.6	18.5-77.0	41.6	71-261	149
Salvinia natans	10	6.0-7.7	7.1	20.0-121.1	64.0	87-415	268
Isoetes japonica	9	6.8-8.9	7.5	16.0-31.5	24.0	50-103	79
Riccia fluitans	4	6.2-7.8	6.8	20.0-39.5	29.5	109-159	128
Ricciocarpus natans	4	6.7-9.1	7.5	27.5-74.0	39.0	83-368	184

60. Rintanen, T. 1982. Jarvitutkimusaineisto Lapin Laanista. Manuscript, Botanical Archives, Bot. Mus., Univ. Helsinki.

Rintanen, T. 1982. Botanical Lake Types in Finnish Lapland. Ann. Bot. Fennici 19:247-274.

Rintanen, T. 1976. Lake Studies in Eastern Finnish Lapland I. Aquatic Flora: Phanerogams and Charales. Ann. Bot. Fennici 13:137-148.

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The published papers by Tapio Rintanen gave summary results and classifications but did not include raw data. The matrix of lakes and species, along with pH, conductivity, transparency and colour, is on file in the Floristic Archives, Botanical Museum, University of Helsinki (H) and was made available to the author through the courtesy of Arto Kurtto, the Assistant Curator. From the mass of data the following table of aquatic plant species and their pH ranges and means, for the 494 lakes surveyed, has been produced. The mean pH of the waters in which the aquatic plants were found ranged from pH 5.2 to 9.3 and the full range was from pH 4.4 to 10.4. Most aquatic plants have a wide pH tolerance range; the most common and widespread species have pH ranges of 4 to 6 pH units. The pH range increases as the number of sample locations at which a species is collected increases.

Species	Samples	pH		
		Mean	Minimum	Maximum
Alisma plantago-aquatica	27	6.9	6.1	8.7
Schoenoplectus lacustris	45	7.1	6.0	8.4
Eleocharis mamillata	15	7.3	6.3	9.6
Sparganium friesii	43	7.0	5.6	8.4
Sparganium minimum	16	7.2	6.2	9.8
Sagittaria natans	39	7.0	6.4	8.7
Alopecuris aequalis	45	6.9	5.2	8.6
Polygonum amphibium	10	6.7	6.1	7.6
Potamogeton friesii	10	7.7	6.8	9.8
Potamogeton lucens	6	7.1	6.6	7.4
Eleocharis palustris	59	7.1	5.9	9.8
Elatine orthosperma	2	7.0	6.6	7.3
Juncus bulbosus	1	6.9	6.9	6.9
Potamogeton vaginatus	1	7.7	7.7	7.7
Callitriche hamulata	1	7.0	7.0	7.0
Scirpus tabernaemontani	2	8.4	7.0	9.8
Myosotis scorpioides	1	7.3	7.3	7.3
Lythrum salicaria	11	7.2	6.4	7.8
Scirpus sylvaticus	1	7.1	7.1	7.1
Montia fontana	5	7.5	7.0	8.4
Cicuta virosa	57	7.0	5.9	9.6
Carex acuta	20	7.2	5.8	8.6
Carex vescicaria	17	6.7	5.2	7.6
Phalaris arundinacea	15	7.0	5.2	8.7
Calla palustris	15	7.1	6.0	8.5
Rumex aquaticus	34	7.1	5.9	9.8
Caltha palustris	125	6.9	6.0	9.4
Fissidens osmundoides	1	7.2	7.2	7.2
Campylium stellatum	3	7.5	7.3	7.6
Campylium polygamum	4	7.0	6.3	7.6

continued

Species	Samples	pH		
		Mean	Minimum	Maximum
Calliergon trifariuim	5	6.8	6.3	7.2
Calliergon cordifolium	2	6.9	6.8	6.9
Lemna minor	5	8.1	7.2	9.8
Zannichellia palustris	2	9.3	8.7	9.8
Potamogeton pusillus	3	8.4	6.8	9.8
Nitella opaca	9	7.0	6.3	7.6
Chara intermedia	1	7.1	7.1	7.1
Limosella aquatica	1	6.6	6.6	6.6
Elatine triandra	2	6.9	6.1	7.6
Nymphaea tetragona	3	7.0	6.2	7.4
Butomus umbellatus	5	7.0	6.0	7.6
Potamogeton obtusifolius	15	7.3	6.6	8.7
Potamogeton filiformis	9	7.2	6.5	7.7
Lemna trisulca	19	7.0	6.3	9.8
Sparganium hyperboreus	9	6.3	5.7	7.7
Isoetes spp.	1	6.6	6.6	6.6
Calliergonella cuspidata	10	7.0	6.2	7.6
Scapania irrigua	1	5.8	5.8	5.8
Cladopodiella fluitans	2	5.5	5.2	5.8
Chiloscyphus pallescens	5	7.0	6.5	7.6
Sphagnum riparium	19	6.1	4.8	7.4
Sphagnum platyphyllum	28	6.1	4.9	7.4
Sphagnum papillosum	7	5.5	4.4	6.2
Sphagnum mauus	19	6.1	4.4	7.0
Sphagnum lindbergia	2	5.2	5.0	5.4
Sphagnum contortum	1	6.8	6.8	6.8
Sphagnum compactum	3	5.9	4.8	7.1
Sphagnum balticum	1	6.3	6.3	6.3
Sphagnum aongstroemii	1	5.5	5.5	5.5
Sphagnum annulatum	10	5.7	4.4	7.0

continued

Species	Samples	pH		
		Mean	Minimum	Maximum
Rhynchostegium riparoides	6	7.1	6.6	7.4
Polytrichum commune	1	6.8	6.8	6.8
Octodiceras fontanum	2	7.6	7.3	7.8
Lepidodictyum riparum	4	7.0	6.2	7.5
Fontinalis dalecarlica	11	6.8	5.7	7.5
Drepanocladus tundrae	19	7.1	6.4	7.8
Scorpidium scorpioides	113	6.8	5.6	8.4
Fontinalis hypnoides	43	7.0	6.0	8.4
Fontinalis antipyretica	105	7.0	5.7	8.5
Drepanocladus revolvens	2	7.2	7.1	7.3
Drepanocladus fluitans	4	5.9	5.0	6.8
Drepanocladus exannulatus	12	6.2	5.0	7.8
Dichelyma falcatum	2	6.3	6.1	6.4
Drepanocladus trichophyllus	91	6.7	5.0	9.0
Drepanocladus tenuinervis	82	6.9	6.0	8.0
Drepanocladus procerus	182	6.6	4.8	9.0
Drepanocladus capillifolius	84	6.9	5.8	9.0
Drepanocladus aduncus	33	6.4	6.1	7.6
Calliergon stramineum	5	6.4	5.7	7.1
Calliergon richardsoni	9	6.7	6.1	7.8
Calliergon giganteum	16	6.9	6.3	7.7
Calliergon megalophyllum	88	6.9	5.6	7.8
Chara strigosa	14	7.6	7.0	8.5
Nitella flexilis	35	7.0	6.2	7.8
Chara globularis	29	7.2	6.1	9.8
Lobelia dortmanna	35	7.0	6.1	7.5
Elatine hydropiper	44	6.9	5.9	8.7
Utricularia minor	23	6.5	5.7	8.2
Subularia aquatica	138	6.8	5.6	9.0
Isoetes echinospora	172	6.8	5.0	9.8

continued

Species	Samples	pH		
		Mean	Minimum	Maximum
Utricularia vulgaris	147	6.8	5.1	9.4
Isoetes lacustris	165	6.7	4.4	8.6
Eleocharis acicularis	114	6.9	5.0	9.8
Ranunculus reptans	220	6.9	5.6	9.4
Myriophyllum verticillatum	12	6.7	5.8	7.8
Callitriche cophocarpa	11	6.7	5.8	7.3
Callitriche hermaphroditica	21	6.8	6.0	8.4
Ceratophyllum demersum	16	7.1	6.2	8.2
Stratiotes aloides	23	7.2	6.1	8.2
Potamogeton compresus	35	7.2	6.4	8.5
Utricularia intermedia	38	6.4	4.4	7.3
Myriophyllum spicatum	40	7.1	6.1	9.8
Potamogeton berchtoldii	137	6.9	5.7	9.4
Ranunculus peltatus	135	6.8	5.7	10.4
Callitriche palustris	106	6.8	5.1	9.6
Myriophyllum alterniflorum	184	6.7	5.7	7.6
Potamogeton praelongus	69	6.9	5.8	8.5
Sparganium emersum	61	6.9	5.6	9.4
Potamogeton natans	89	7.0	5.7	9.4
Hippuris vulgaris	104	6.9	5.7	9.8
Potamogeton gramineus	126	7.0	5.7	9.4
Nymphaea candida	117	6.9	5.6	9.6
Nuphar pumila	152	6.9	4.4	9.6
Potamogeton alpinus	155	6.9	5.7	8.5
Nuphar lutea	144	6.9	4.4	9.8
Potamogeton perfoliatus	216	7.0	6.0	10.4
Carex lasiocarpa	176	6.6	4.9	9.8
Phragmites australis	196	7.0	5.9	9.8
Sparganium angustifolium	240	6.6	4.9	9.6
Menyanthes trifoliata	253	6.6	4.4	9.6

continued

Species	Samples	pH		
		Mean	Minimum	Maximum
Lysimachia thyrsiflora	219	6.9	5.1	9.8
Carex aquatilis	256	6.8	4.4	10.4
Potentilla palustris	313	6.8	5.4	10.4
Equisetum fluviatile	374	6.9	5.6	10.4
Carex rostrata	376	6.7	4.4	10.4

61. Beal, E.O. 1977. A Manual of Marsh and Aquatic Vascular Plants of North Carolina with Habitat Data. Technical Bulletin No. 247, North Carolina Agricultural Experiment Station.

This book gives keys, distribution data within North Carolina primarily, but other areas as well, illustrations, and where available, data on the range of pH, chloride, organic matter percentage and conductivity of the water in which aquatic and marsh plants of North Carolina are found. The pH values are given as bar graphs in this paper with a median indicated when the number of records is 5 or greater and a median 2/3 range when the number of records is 13 or greater. The values in the following table have been read off the bar graphs to the nearest 0.1 pH unit.

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Isoetes engelmannii	>12	6.8	6.7-7.1	5.1-7.4
Azolla caroliniana	5-12	6.5		6.1-7.2
Typha latifolia	>12	6.7	6.1-7.2	5.0-10.0
Typha angustifolia	5-12	6.7		6.1-8.1
Typha domingensis	5-12	7.1		6.7-8.6
Sparganium chlorocarpum	1	6.6		6.6
Sparganium americanum	>12	6.2	5.1-6.8	4.8-7.3
Potamogeton pectinatus	2	6.7		6.6-6.7
Potamogeton diversifolius	>12	6.2	6.0-7.2	5.0-9.1
Potamogeton confervoides	1	5.6		5.6
Potamogeton epihydrus	5-12	6.6		5.2-7.2
Potamogeton foliosus	1	6.1		6.1
Potamogeton pusillus	>12	6.7	6.1-7.2	5.9-8.4
Potamogeton perfoliatus	2	6.8		6.7-6.8
Potamogeton pulcher	>12	6.5	6.1-6.8	6.0-7.3
Potamogeton nodosus	2	6.8		6.7-6.8
Potamogeton illinoensis	2	8.4		7.4-9.4
Ruppia maritima	5-12	6.9		6.7-7.6
Zannichellia palustris	1	7.5		7.5

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Najas quadalupensis	>12	7.8	6.6-8.5	6.6-10.0
Najas gracillima	5-12	7.1		6.2-8.3
Alisma subcordatum	5-12	6.9		6.2-7.5
Echinodorus cordifolius	5-12	6.6		5.8-7.3
Sagittaria calycina	1	8.5		8.5
Sagittaria graminea	5-12	6.7		5.6-7.1
Sagittaria subulata	2	7.2		7.1-7.2
Sagittaria teres	2	5.0		4.9-5.0
Sagittaria falcata	>12	6.8	6.5-6.9	6.1-8.6
Sagittaria latifolia	>12	6.8	6.2-7.3	4.7-8.6
Sagittaria engelmanniana	2	5.9		5.6-6.2
Sagittaria longirostra	5-12	7.0		6.0-7.7
Elodea densa	>12	6.8	6.5-7.1	6.0-8.4
Elodea canadensis	2	6.8		6.6-6.9
Elodea nuttallii	5-12	7.0		6.6-7.9
Limnobium spongia	5-12	6.7		6.0-6.9
Vallisneria americana	3	6.7		5.6-7.9
Hydrochloa caroliniensis	3	6.4		6.1-6.8
Glyceria melicaria	1	6.5		6.5
Glyceria striata	>12	7.1	6.9-7.5	6.3-8.6
Leersia hexandra	3	5.5		5.0-5.7
Leersia oryzoides	>12	6.9	5.9-7.2	5.1-7.9
Leersia virginica	1	8.6		8.6
Spartina patens	4	7.0		6.6-7.2
Spartina alterniflora	3	7.4		7.2-7.6
Spartina pectinata	1	7.0		7.0
Spartina cynosuroides	4	6.6		4.9-7.7
Echinochloa walteri	5-12	6.6		5.1-9.3
Echinochloa crussgalli	5-12	6.8		4.7-7.3
Paspalum dissectum	1	6.4		6.4
Paspalum distichum	3	6.7		6.0-7.7
Paspalum vaginatum	1	9.3		9.3

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Alopecurus carolinianus	2	6.8		6.4-7.1
Phalaris arundinacea	1	7.3		7.3
Sacciolepis striata	5-12	6.2		4.1-6.5
Panicum hemitomon	5-12	5.2		5.0-6.2
Panicum hians	5-12	6.2		4.0-7.6
Panicum stipitatum	1	5.3		5.3
Panicum agrostoides	4	5.1		4.7-5.4
Panicum virgatum	3	7.1		6.5-7.6
Zizania aquatica	5-12	6.6		6.4-7.4
Zizaniopsis miliacea	4	6.6		6.1-6.8
Carex leptalea	2	6.0		5.5-6.5
Carex stipata	2	6.4		6.0-6.8
Carex laevivaginata	1	7.1		7.1
Carex vulpinoidea	>12	6.9	6.8-7.2	6.6-8.8
Carex annectens	2	6.9		6.8-6.9
Carex albolutescens	5-12	6.0		4.2-7.9
Carex scoparia	2	6.8		6.4-7.1
Carex lupilina	5-12	7.0		6.1-7.5
Carex lurida	>12	6.9	6.2-7.2	4.9-8.4
Carex comosa	2	6.4		6.3-6.4
Eleocharis robbinsii	1	4.9		4.9
Eleocharis equisetoides	1	5.4		5.4
Eleocharis quadrangulata	5-12	6.8		6.5-7.3
Eleocharis acicularis	5-12	6.8		5.3-7.8
Eleocharis baldwinii	5-12	6.3		5.6-6.8
Eleocharis tuberculosa	>12	6.0	5.1-6.8	4.9-7.6
Eleocharis melancarpa	1	6.1		6.1
Eleocharis obtusa	>12	6.8	6.1-7.3	4.1-8.7
Eleocharis tricostata	2	6.1		5.1-7.0
Eleocharis tenuis	2	6.6		6.1-7.0

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Eleocharis vivipara	3	6.0		5.7-6.4
Eleocharis parvula	3	7.2		6.6-7.6
Eleocharis microcarpa	>12	6.1	5.1-6.6	4.6-7.4
Eleocharis fallax	3	6.8		6.2-7.5
Eleocharis albida	3	7.7		6.8-8.6
Eleocharis flavescens	5-12	7.0		4.0-8.5
Dulichium arundinaceum	>12	6.0	5.0-6.7	4.7-7.5
Cyperus pseudovegetus	3	7.0		6.4-7.7
Cyperus polystachyos	5-12	6.6		4.0-7.6
Cyperus filicinus	1	6.7		6.7
Cyperus erythrorhizos	1	7.3		7.3
Cyperus odoratus	1	8.6		8.6
Cyperus strigosus	3	6.7		6.3-7.0
Rhynchospora corniculata	5-12	6.1		5.1-7.4
Rhynchospora macrostachya	4	6.1		4.7-7.3
Rhynchospora traceyi	2	5.7		4.9-6.5
Cladium jamaicense	5-12	7.0		6.5-8.4
Fuirena squarrosa	4	6.4		5.2-7.6
Fuirena pumila	1	10.0		10.0
Fimbristylis spadicea	1	7.6		7.6
Scirpus purshianus	>12	7.1	6.8-7.3	6.6-8.4
Scirpus subterminalis	4	5.1		4.9-6.1
Scirpus americanus	>12	7.1	6.8-8.1	5.1-8.5
Scirpus validus	>12	7.1	6.6-7.6	6.1-8.6
Scirpus etuberculatus	5-12	5.6		4.8-7.4
Scirpus robustus	5-12	7.8		6.3-8.3
Scirpus cyperinus	>12	6.5	6.0-7.2	4.8-8.4
Scirpus expansus	5-12	6.9		5.8-7.4
Scirpus georgianus	>12	7.1	6.7-7.2	6.3-8.8
Scirpus polyphyllus	5-12	6.8		6.7-7.4

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Scirpus divaricatus	1	8.2		8.2
Eriophorum virginicum	1	6.4		6.4
Acorus calamus	5-12	6.8		5.7-7.2
Orontium aquaticum	5-12	6.0		4.7-7.3
Peltandra virginica	>12	6.5	6.1-6.8	5.2-7.6
Peltandra sagittaefolia	2	6.0		5.1-6.9
Spirodela oligorrhiza	2	6.5		6.1-6.8
Spirodela polyrhiza	>12	6.6	6.1-6.8	6.0-8.2
Lemna gibba	2	6.6		6.4-6.7
Lemna perpusilla	>12	6.5	5.7-6.5	4.5-7.2
Lemna valdiviana	5-12	6.6		5.2-7.3
Wolffia papulifera	3	6.5		6.1-6.7
Wolffia columbiana	2	6.6		6.5-6.7
Wolffia floridana	5-12	6.5		6.1-6.6
Mayaca aubletii	5-12	6.0		5.0-6.5
Mayaca fluviatilis	2	5.7		5.6-5.7
Xyiris smalliana	1	5.0		5.0
Xyris iridifolia	5-12	6.4		5.0-8.2
Xyris platylepis	5-12	5.1		4.7-6.6
Eriocaulon decangulare	5-12	6.5		4.9-7.6
Eriocaulon compressum	2	5.2		4.9-5.4
Eriocaulon pellucidum	1	6.8		6.8
Lachnocaulon anceps	1	5.8		5.8
Lachnocaulon minus	1	4.5		4.5
Syngonanthus flavidulus	1	4.7		4.7
Aneilema keisak	>12	6.4	6.1-7.2	5.3-7.6
Heteranthera reniformis	5-12	7.0		6.0-7.5
Pontederia cordata	>12	6.8	6.1-7.3	5.9-7.9
Eichhornia crassipes	1	6.6		6.6
Juncus roemerianus	1	6.6		6.6

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Juncus coriaceus	>12	6.6	6.0-7.2	5.0-8.7
Juncus effusus	>12	6.6	6.0-7.2	4.7-8.4
Juncus gymnocarpus	5-12	6.7		5.5-7.0
Juncus bufonius	1	5.3		5.3
Juncus repens	>12	6.0	5.1-6.7	4.7-8.2
Juncus biflorus	5-12	6.9		6.0-7.2
Juncus marginatus	>12	6.8	6.1-7.0	6.0-8.7
Juncus abortivus	5-12	6.0		4.0-6.7
Juncus acuminatus	>12	6.9	6.1-7.3	4.2-8.4
Juncus debilis	>12	6.0	5.3-6.7	4.2-7.0
Juncus brevicaudatus	1	6.6		6.6
Juncus canadensis	>12	6.6	5.1-6.9	4.7-7.6
Juncus subcaudatus	4	5.7		4.6-7.2
Juncus brachycarpus	1	7.0		7.0
Juncus scirpoides	5-12	6.5		5.0-8.1
Juncus megalocephalus	1	8.1		8.1
Juncus diffusissimus	3	7.0		6.0-7.7
Juncus elliottii	1	5.6		5.6
Iris prismatica	2	5.1		5.0-5.1
Iris virginica	5-12	5.7		4.9-7.2
Saururus cernuus	>12	6.3	6.0-7.0	4.7-7.5
Rumex verticillatus	3	6.7		6.1-7.2
Polygonum arifolium	5-12	6.5		6.0-7.3
Polygonum sagittatum	>12	6.8	6.2-7.3	5.1-8.4
Polygonum densiflorum	1	6.4		6.4
Polygonum hirsutum	1	7.4		7.4
Polygonum hydropiperoides	>12	6.5	5.9-6.9	4.5-7.9
Polygonum punctatum	>12	6.8	6.5-7.7	6.0-8.7
Alternanthera philoxeroides	5-12	6.6		5.9-6.8
Ceratophyllum demersum	5-12	6.6		6.2-8.3

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Ceratophyllum echinatum	2	5.9		5.6-6.1
Nymphaea odorata	>12	6.1	5.1-6.8	4.5-9.4
Nuphar luteum	>12	6.5	5.5-7.2	4.2-7.7
Nelumbo pentapetala	5-12	6.1		4.5-7.3
Brasenia schreberi	>12	6.0	5.1-6.2	4.8-7.2
Cabomba caroliniana	5-12	7.1		5.7-9.2
Ranunculus sceleratus	1	7.3		7.3
Ranunculus pusillus	3	6.8		6.6-7.1
Ranunculus subcordatus	2	6.4		6.0-6.8
Rorippa nasturtium-aquaticum	3	6.9		6.7-7.1
Podostemum ceratophyllum	>12	7.0	6.9-7.2	6.8-7.8
Aeschynomene virginica	3	6.9		6.3-7.8
Aeschynomene indica	1	8.5		8.5
Callitriche heterophylla	>12	6.5	6.3-7.1	5.2-7.2
Elatine triandra	1	7.2		7.2
Peplis diandra	5-12	6.2		5.8-6.6
Decodon verticillatus	>12	6.2	5.7-6.7	4.7-7.1
Cuphea carthogensis	5-12	6.1		5.2-7.7
Lythrum salicaria	1	6.6		6.6
Lythrum lineare	2	8.5		8.3-8.6
Rotala ramosior	5-12	6.8		6.2-7.6
Ludwigia decurrens	>12	6.4	6.0-7.2	5.1-7.8
Ludwigia leptocarpa	2	6.5		5.3-7.6
Ludwigia uruguayensis	5-12	6.8		6.1-7.3
Ludwigia alternifolia	>12	6.5	6.0-7.1	4.7-10.0
Ludwigia glandulosa	5-12	6.6		6.0-7.3
Ludwigia linearis	5-12	6.0		4.7-6.7
Ludwigia sphaerocarpa	2	5.2		4.9-5.5
Ludwigia pilosa	5-12	6.8		4.8-7.7
Ludwigia brevipes	5-12	6.1		5.2-6.2

continued

Species	N	pH		
		Median	Median 2/3 Range	Full Range
Ludwigia repens	2	6.8		6.7-6.9
Ludwigia palustris	>12	6.7	6.1-7.3	5.0-8.6
Myriophyllum brasiliense	>12	6.4	6.0-7.0	5.2-7.7
Myriophyllum heterophyllum	>12	6.1	5.7-6.4	5.0-9.0
Myriophyllum laxum	1	4.9		4.9
Myriophyllum pinnatum	2	7.0		6.6-7.3
Proserpinaca palustris	>12	6.1	5.5-6.7	4.3-6.8
Proserpinaca intermedia	4	5.6		4.9-5.9
Proserpinaca pectinata	5-12	5.4		5.0-6.1
Hydrocotyle americana	1	6.8		6.8
Hydrocotyle ranunculoides	1	6.3		6.3
Hydrocotyle umbellata	>12	6.4	6.0-7.4	4.8-9.3
Hydrocotyle bonariensis	1	7.6		7.6
Hottonia inflata	2	6.9		6.6-7.1
Lysimachia terrestris	2	6.3		5.9-6.6
Samolus parviflorus	5-12	6.7		6.1-8.7
Nymphoides aquatica	5-12	5.7		4.9-6.4
Nympoides cordata	4	5.5		4.9-6.0
Hydrolea quadrivalvis	5-12	6.5		5.8-8.3
Micranthemum umbrosum	>12	6.3	6.1-7.2	5.3-8.3
Bacopa monnieri	5-12	6.9		5.4-7.7
Bacopa caroliniana	1	5.9		5.9
Bacopa cyclophylla	1	6.6		6.6
Mimulus ringens	>12	7.1	6.8-7.2	5.3-8.2
Mimulus alatus	5-12	7.3		6.1-7.9
Mecardonia acuminata	1	7.0		7.0
Lindernia dubia	>12	7.0	6.2-7.4	5.1-9.1
Gratiola neglecta	>12	6.3	5.9-7.1	5.1-7.7
Gratiola virginiana	1	6.6		6.6
Gratiola viscidula	5-12	6.8		6.0-7.3

continued

Species	N	pH Median	Median 2/3 Range	Full Range
Utricularia subulata	1	4.6		4.6
Utricularia resupinata	1	6.8		6.8
Utricularia cornuta	3	6.2		5.2-7.
Utricularia olivacea	1	4.9		4.9
Utricularia inflata	5-12	6.5		6.1-7.6
Utricularia purpurea	5-12	6.6		5.0-7.5
Utricularia gibba	5-12	5.6		5.0-6.2
Utricularia fibrosa	5-12	5.2		4.9-6.6
Utricularia biflora	>12	6.1	6.0-6.6	4.6-7.0
Justicia americana	>12	7.0	6.6-7.3	6.2-7.5
Justicia ovata	5-12	6.6		5.1-7.4
Lobelia cardinalis	>12	6.7	6.6-7.0	5.8-7.8
Lobelia nuttallii	1	7.0		7.0
Lobelia amoena	1	6.8		6.8
Lobelia elongata	1	6.2		6.2

62. Forsberg, C. 1960. Subaquatic Macrovegetation in Osbysjon. Djursholm. Oikos 11(2):183-199.

A quantitative study of four species of aquatic plants, *Chara fragilis*, *Nitella mucronata*, *Ceratophyllum demersum*, and *Myriophyllum verticillatum*, was undertaken in Lake Osby (Osbysjon). Standing crops and rates of production were determined along with tissue concentrations of several nutrients. Other species present in the lake included *Stratiotes aloides*, *Phragmites communis*, *Typha angustifolia*, *Potamogeton natans* and *Nymphaea alba*. The pH range in the lake over the growing season was 7.6-8.0.

This paper also gives a table reporting pH values recorded in two other papers for two of the species in Lake Osby. These papers were:

63. Olsen, S. 1944. Danish Charophyta. Chorological, Ecological and Biological Investigations. Kgl. Danske Vidensk. Selsk. Biol. Skr. 111(1), 1-240,

Nitella mucronata pH 8.6
Chara fragilis pH 5.6-9.2
and

64. Stroede, W. 1931. Okologie der Characeen. Berlin,

Nitella mucronata pH 7.2
Chara fragilis pH 5.8-8.3

65. Bell, R. 1956. Aquatic and Marginal Vegetation of Strip Mine Waters in Southern Illinois. Illinois Academy of Science Transactions. 48:85-91.

The following table gives some pH data on aquatic plants which have colonized strip mine lakes in Illinois.

Species	Number of Lakes	pH Range
Potamogeton foliosis	57	6.4-8.6
Chara spp.	28	6.6-8.2
Potamogeton pusillus	2	7.0
Najas flexilis	2	7.5
Potamogeton americanus	7	6.4-7.7
Potamogeton diversifolius	4	7.7-9.4
Nelumbo lutea	2	7.0
Jussiaea diffusa (*Ludwigia*)	2	7.5
Typha latifolia	66	3.0-8.1
Typha angustifolia	4	4.5-7.6
Eleocharis obtusa	38	3.4-9.4
Leersia oryzoides	10	6.7-7.8
Ludwigia alternifolia	2	9.4
Echinochloa crusgalli	51	3.0-8.6

66. Singer, R., D.A. Roberts and C.W. Boylen. 1983. The Macrophytic Community of an Acidic Lake in Adirondack (New York, U.S.A.): A New Depth Record for Aquatic Angiosperms. Aquatic Botany 16:49-57.

The submerged vegetation of Silver Lake was surveyed to determine the effects of low pH on aquatic biota. The lake is very clear (Secchi >18 m) and low in pH (5.8), conductivity (27 µS/cm), chlorophyll *a* (0.11 µg/L) and total phosphorus (<1 µg/L). The plants found included *Utricularia purpurea*, *Sphagnum* sp., *Lobelia dortmanna*, *Eriocaulon septangulare*, *Utricularia resupinata*, *Potamogeton confervoides*, *Myriophyllum tenellum*, *Nuphar* spp., *Utricularia geminiscapa*, *Eleocharis* spp. and *Nymphoides cordata*.

67. Moyle, J.B. 1945. Some Chemical Factors Influencing the Distribution of Aquatic Plants in Minnesota. Am. Midl. Nat. 34:402-420.

Surveys of 225 lakes and streams in Minnesota were carried out in waters representative of the chemical range found in Minnesota surface waters. Aquatic plants found in these lakes were also recorded. The table below gives the alkalinity and pH medians and ranges for the plants found, and the number of samples on which these values were based.

Species	Alkalinity			pH		
	N	Median	Range	N	Median	Range
Equisetum fluviatile	26	45.0	7.5-297.5	27	7.7	6.8-8.8
Isoetes braunii	11	31.8	8.0-45.0	10	7.6	7.0-8.0
Typha latifolia	70	116.5	10.0-376.0	73	8.3	6.3-9.0
Sparganium chlorocarpum	4	84.4	16.5-144.0	2		7.3-8.4
Sparganium eurycarpum	24	112.6	35.3-376.0	28	8.2	7.2-8.8
Sparganium fluctuans	6	31.1	20.0-45.0	4	7.2	7.0-7.3
Potamogeton alpinus	5	31.8	12.5-113.7	5	7.5	7.0-8.6
Potamogeton amplifolius	34	93.1	12.5-208.7	39	8.2	7.1-8.8
Potamogeton angustifolius	20	108.8	12.5-307.5	3	8.1	7.0-9.0
Potamogeton crispus	5	140.0	113.2-262.5	7	8.2	7.6-8.4
Potamogeton epihydrus	18	28.9	10.0-113.7	20	7.4	6.7-8.6
Potamogeton foliosus	20	127.5	37.5-228.7	23	8.1	7.2-8.8
Potamogeton friesii	11	117.9	71.6-376.1	12	8.3	7.7-8.8
Potamogeton gramineus	47	125.0	30.4-169.9	60	8.2	7.0-8.8
Potamogeton natans	28	118.5	18.7-307.7	25	8.4	6.8-9.0
Potamogeton nodosus	15	117.0	41.2-312.0	11	7.9	7.3-8.5
Potamogeton obtusifolius	3	31.8	30.4-70.0	3	7.2	7.0-7.9
Potamogeton pectinatus	85	140.0	31.8-376.0	101	8.4	6.3-9.0
Potamogeton pusillus	12	110.4	31.5-187.8	14	8.0	7.0-8.8
Potamogeton praelongus	26	114.4	12.5-307.7	31	8.2	7.1-9.0

continued

Species	Alkalinity			pH		
	N	Median	Range	N	Median	Range
Potamogeton richardsonii	70	127.0	31.8-376.0	83	8.2	7.0-9.1
Potamogeton robbinsii	11	72.5	32.5-144.0	14	8.0	7.2-8.4
Potamogeton spirillus	11	32.5	18.7-46.0	10	7.4	7.0-8.3
Potamogeton strictifolius	19	42.2	31.8-262.5	26	8.1	7.3-9.0
Potamogeton vaginatus	6	145.0	107.5-307.7	7	8.4	8.0-9.0
Potamogeton zosteriformis	62	117.7	18.1-245.0	65	8.2	6.9-9.0
Ruppia occidentalis	6	252.8	146.8-376.0	8	8.5	8.1-9.0
Zannichellia palustris	17	190.0	75.0-337.5	21	8.4	7.6-9.0
Najas flexilis	77	122.5	18.7-307.7	83	8.3	7.2-9.0
Najas guadalupensis	7	140.0	75.0-159.8	5	8.2	7.2-8.6
Najas marina	5	228.7	146.8-376.0	9	8.5	8.2-9.0
Alisma plantago-aquatica	13	115.0	31.8-297.5	15	8.2	7.0-8.8
Sagittaria cristata	16	89.6	18.7-183.0	18	8.2	7.2-8.8
Sagittaria cuneata	13	134.4	20.0-376.0	17	8.5	7.3-9.0
Sagittaria latifolia	65	95.0	0.5-297.5	64	8.0	6.3-8.8
Sagittaria rigida	24	89.7	32.5-297.5	26	8.0	7.4-8.8
Elodea canadensis	41	117.9	35.3-297.5	46	8.2	7.0-8.8
Elodea occidentalis	21	101.9	22.5-202.5	33	8.1	7.3-8.8
Vallisneria americana	51	108.2	18.7-277.0	55	8.2	7.0-8.9
Glyceria borealis	22	41.6	8.0-187.5	15	7.6	6.8-8.8
Glyceria grandis	12	111.0	8.0-245.0	10	8.1	7.2-8.8
Leersia oryzoides	27	107.1	30.4-277.0	30	8.4	7.2-9.0
Phalaris arundinacea	10	63.7	22.5-134.4	9	7.7	7.3-8.8
Phragmites communis	40	125.0	0.5-297.5	44	8.2	6.3-9.0
Zizania aquatica	43	143.8	8.0-297.5	42	8.2	7.2-8.8
Eleocharis acicularis	29	81.6	18.7-376.0	33	8.3	7.0-8.0
Eleocharis palustris	71	96.1	0.5-220.0	77	8.2	6.3-9.0
Scirpus acutus	79	122.5	17.1-220.0	90	8.3	7.2-9.1
Scirpus americanus	9	190.0	87.7-277.0	14	8.4	7.4-8.9
Scirpus fluviatilis	42	127.5	30.4-220.0	53	8.4	7.0-9.1

continued

Species	Alkalinity			pH		
	N	Median	Range	N	Median	Range
Scirpus heterochaetus	6	121.1	41.2-198.7	7	8.1	7.3-8.6
Scirpus paludosus	3	150.0	146.8-197.5	5	8.6	8.4-9.0
Scirpus subterminalis	6	23.4	8.0-42.5	4	6.8	6.8-7.5
Acorus calamus	14	114.9	20.0-202.5	17	8.5	7.3-8.8
Lemna minor	32	135.7	41.2-262.5	34	8.2	6.3-9.0
Lemna trisulca	19	134.4	41.2-297.5	23	8.2	7.2-8.8
Spirodela polyrhiza	22	130.8	49.0-297.5	21	8.2	6.3-8.8
Wolffia columbiana	7	167.5	85.0-220.0	6	8.3	7.2-8.4
Eriocaulon septangulare	9	22.5	10.0-44.3	9	7.5	6.7-7.8
Heteranthera dubia	41	117.0	22.5-245.0	36	8.3	7.6-9.0
Pontederia cordata	4	58.8	18.7-92.5	3	7.3	7.2-7.9
Polygonum coccineum	12	111.5	75.0-208.7	14	8.2	7.3-8.8
Polygonum natans	21	113.7	30.0-260.0	23	8.2	7.7-8.8
Ceratophyllum demersum	85	134.4	22.5-376.0	93	8.2	6.3-9.0
Brasenia schreberi	8	110.7	32.5-144.0	9	8.4	7.6-8.8
Nuphar microphyllum	11	22.5	7.5-41.1	6	6.8	6.8-7.3
Nuphar rubrodiscum	5	22.5	0.5-31.8	6	7.0	6.8-7.3
Nuphar variegatum	42	111.4	7.5-220.0	48	8.0	6.8-8.6
Nuphar odorata	4	63.4	37.5-162.5	4	8.0	7.6-8.4
Nymphaea tuberosa	31	115.0	18.7-297.0	38	8.2	6.3-9.0
Bidens beckii	19	90.6	31.8-190.0	18	8.0	7.0-8.8
Ranunculus longirostris	3	126.8	113.2-144.0	3	8.2	7.9-8.4
Ranunculus trichophyllus	11	63.8	125.0-297.5	10	8.0	7.1-8.8
Hippuris vulgaris	12	137.5	30.0-297.0	16	8.4	6.8-8.8
Myriophyllum exalbescens	68	113.2	22.5-376.0	72	8.3	7.2-8.9
Utricularia intermedia	11	113.7	8.0-245.0	10	8.3	7.7-8.6
Utricularia vulgaris	29	144.0	16.5-297.5	33	8.1	6.8-8.8
Lobelia dortmanna	6	18.7	12.5-42.0	6	7.2	6.8-7.5

68. Pip, Eva. 1979. Survey of the Ecology of Submerged Aquatic Macrophytes in Central Canada. Aquatic Botany 7:339-357.

Submerged macrophytes were recorded in 305 sites in southern Manitoba and adjacent areas. The distribution was correlated with the type of water body and substrate and with eight water chemistry parameters. The presence of many plants is correlated with that of other plants and, of the chemical parameters, most highly with total alkalinity. The table below gives maximum, minimum and mean, pH and alkalinity values for species, when the mean pH or alkalinity values of the sites at which they were found was significantly different than the mean pH or alkalinity values of the sites at which they were not found.

Species	Alkalinity			pH		
	Mean	Max.	Min.	Mean	Max.	Min.
Zizana aquatica	89	222	0			
Calla palustris	50	146	0			
Nymphaea odorata	40	100	4			
Nymphaea tetragona	60	88	12			
Nuphar variegatum	93	298	6			
Brasenia schreberi	35	80	8			
Bidens beckii	77	139	25			
Zosterella dubia	78	112	26			
Chara spp.				8.4	10.2	6.6
Sparganium spp.	109	336	10	7.7	9.7	6.2
Ruppia martima	233	800	86	8.5	9.4	7.7
Potamogeton alpinus				7.3	7.8	6.8
Potamogeton epihydrus	26	72	0	7.6	9.2	6.6
Potamogeton friesii				8.6	9.5	6.7
Potamogeton pectinatus				8.4	10.2	6.6
Potamogeton praelongus	101	254	30	8.5	9.6	7.2
Potamogeton richardsonii	117	448	15	8.3	10.2	6.7
Potamogeton robbinsii				8.9	9.8	8.0

continued

Species	Alkalinity			pH		
	Mean	Max.	Min.	Mean	Max.	Min.
Najas flexilis	93	222	16	8.4	9.8	7.4
Sagittaria spp.				8.0	9.3	6.2
Lemna minor				7.9	9.0	5.7
Spirodela polyrhiza	71	176	4	7.9	9.2	6.6
Polygonum amphibium	114	328	12	7.9	9.3	5.7
Myriophyllum exalbescens				8.3	10.2	6.2
Sium sauve				7.8	9.0	6.6
Utricularia intermedia				7.5	8.8	6.5
Utricularia minor				7.5	8.3	6.9
Utricularia vulgaris				7.9	9.5	6.5
Potamogeton amplifolius	59	119	10			
Potamogeton gramineus	109	313	22			
Potamogeton natans	111	228	4			
Potamogeton obtusifolius	45	70	20			
Potamogeton spirillus	29	85	10			
Potamogeton zosteriformis	91	176	25			
Sagittaria rigida	47	112	22			
Elodea canadensis	105	228	22			
Vallisneria americana	80	200	10			

69. Clarkson, R.B. and J.A. Moore. 1971. Vascular Aquatic Plants in Acid Mine Water of the Monongahela River, West Virginia. Bulletin 2. Water Research Institute, West Virginia University. 11 pp.

The distribution of aquatic plants in three West Virginia acid mine water polluted rivers was studied and water chemistry analyses, including pH, were done at six sites. Discriminant analysis showed substrate to be the primary physical factor determining distribution and pH was a non-limiting factor.

Species	pH Ranges (composites of several sites)
Potamogeton nodosus	3.1-6.4
Ludwigia palustris	3.1-6.4
Typha latifolia	3.1-6.8
Eleocharis acicularis	3.1-6.8
Eleocharis obtusa	3.1-6.4
Juncus effusus	3.1-6.4
Sparganium americana	3.1-6.2
Potamogeton epihydrus	3.1-6.2
Sagittaria gramineus	3.1-6.8
Sagittaria latifolia	3.1-6.2
Myriophyllum heterophyllum	3.1-6.8

70. Lohammar, G. 1938. Wasserchemie Und Hohere Vegetation Schwedischer. Seen. Symbolae Botanicae Upsalienses III:(1), 1-252.

Higher aquatic plants were surveyed in 151 lakes of Sweden and a number of water chemistry parameters were also measured at these lakes including pH. The pH data for each species has been extracted from the tables of lake chemistry data and plant distribution from the species presence/absence matrix. This data is presented in the table below which gives the overall range of pH for each species.

Species	pH Range	Species	pH Range
Equisetum limosum	4.9-8.9	Litorella uniflora	6.0-8.8
Phragmites communis	4.9-8.9	Lobelia dortmanna	6.0-7.9
Scirpus lacustris	4.9-8.9	Callitriche verna	5.7-8.2
Carex hudsonii	4.9-8.3	Elatine hydropiper	5.7-8.0
Carex lasiocarpa	4.9-8.3	Elatine triandra	5.7-8.0
Carex pseudocyperus	6.3-8.9	Ranunculus reptans	5.7-8.8
Carex rostrata	5.7-8.3	Scirpus acicularis	5.7-8.8
Tillaea aquatica	5.7-7.0		

continued

Species	pH Range	Species	pH Range
Glyceria fluitans	5.7-8.2	Subularia aquatica	5.7-8.8
Glyceria maxima	6.5-8.7	Nuphar luteum	4.9-8.9
Scirpus palustris	5.7-9.0	Nymphaea alba	5.7-8.9
Typha angustifolia	6.0-8.9	Polygonum amphibium	6.2-8.8
Typha latifolia	6.3-8.9	Potamogeton natans	5.7-8.9
Acorus calamus	6.2-9.0	Sparganium affine	5.7-8.1
Alisma plantago-aquatica	5.7-8.9	Sparganium friesii	5.7-8.1
Butomus umbellatus	6.3-8.9	Sparganium minimum	5.7-7.7
Calla palustris	6.3-8.8	Sparganium simplex	5.7-8.8
Cicuta virosa	5.7-9.0	Callitriche autumnalis	6.8-8.2
Hippuris vulgaris	5.7-8.9	Elodea canadensis	6.3-8.9
Iris pseudacorus	6.2-8.9	Juncus supinus	6.0-8.1
Menyanthes trifoliata	4.9-8.3	Myriophyllum spicatum	6.4-8.7
Lysimachia thyrsiflora	5.7-9.0	Myriophyllum alterniflorum	5.7-8.8
Oenanthe aquatica	6.2-8.9	Myriophyllum verticillatum	6.3-8.9
Ranunculus lingua	6.2-8.9	Potamogeton alpinus	5.7-8.5
Rumex hydrolapathum	6.3-8.9	Potamogeton crispus	6.5-8.6
Sagittaria sagittifolia	5.7-8.8	Potamogeton filiformis	6.7-8.8
Sium latifolium	6.3-8.9	Potamogeton gramineus	6.0-8.8
Sparganium ramosum	6.2-8.9	Potamogeton lucens	6.3-8.9
Isoetes echinospora	5.7-813	Potamogeton pectinatus	6.5-8.9
Isoetes lacustre	4.9-7.9	Potamogeton pusillus	6.2-8.9
Potamogeton perfoliatus	5.7-8.3	Ceratophyllum demersum	5.7-8.9
Ranunculus circinatus	6.3-8.9	Lemna minor	6.2-8.9
Ranunculus peltatus	5.7-7.9	Lemna trisulca	6.2-8.9
Potamogeton mucronatus	6.3-8.9	Spirodela polyrhiza	6.3-8.9
Potamogeton obtusifolius	6.2-8.5	Ricciocarpus natans	6.3-8.9
Potamogeton zosteriformis	6.2-8.4	Alopecuris aequalis	6.4-7.1
Hottonia palustris	6.3-8.9	Limosella aquatica	6.4-7.0
Hydrocharis morsus-ranae	6.3-8.9	Nuphar pumilum	5.7-7.6
Stratiotes aloides	6.3-8.9	Sagittaria natans	5.7-7.1
Utricularia vulgaris	5.7-8.9	Potamogeton praelongus	6.2-8.3

71. Bordner, J.S., W.W. Morris, L.M. Wood and J.H. Steenis. 1932. Land Economic Inventory of Northern Wisconsin: Sawyer County. Wisconsin. Dep't of Agriculture and Markets. 138 pp.

This survey of the lakes and aquatic life in Sawyer County, Wisconsin has several tables in it; one contains pH data for each lake and another contains a plant species list. From these data the following pH ranges of some aquatic plant species can be compiled.

Species	pH Range	Species	pH Range
Elatine minima	5.6-9.8	*Elodea canadensis*	7.3-9.8
Eleocharis acicularis	6.0-9.3	*Heteranthera dubia*	7.5-9.8
Eriocaulon septangulare	5.6-9.3	*Myriophyllum alterniflorum*	7.5-7.7
Gratiola aureu	7.5	*Myriophyllum spicatum*	7.3-9.8
Isoetes spp.	5.6-9.8	*Myriophyllum verticillatum*	6.5-8.7
Juncus pelocarpus	5.6-9.8	*Najas flexilis*	7.5-9.8
Littorella americana	6.4-8.7	*Nitella spp.*	6.5
Lobielia dortmanna	5.8-9.8	*Polygonum natans*	7.1-9.8
Myriophyllum tenellum	5.6-8.1	*Potamogeton amplifolius*	6.7-9.8
Ranunculus reptans	6.1	*Potamogeton capillaceus*	6.3
Sagittaria cuneata	6.5-8.7	*Potamogeton epihydrus*	6.4-9.2
Sagittaria graminea	5.6-9.8	*Potamoyeton foliosus*	9.3
Bidens beckii	7.3-9.8	*Potamogeton gramineus*	6.4-9.8
Ceratophyllum demersum	7.5-9.8	*Potamogeton natans*	6.0-9.8
Chara spp.	6.1-9.8	*Potamogeton obtusifolius*	7.7-7.9
Potamogeton pectinatus	8.4-9.8	*Dulichium arundinaceum*	5.8-9.8
Potamogeton praelongus	7.3-9.8	*Eleocharis palustris*	5.8-9.8
Potamogeton pusillus	6.4-9.8	*Eleocharis robbinsii*	6.4-6.5
Potamogeton richardsonii	7.4-9.8	*Equisetum limosum*	6.4-9.8
Potamogeton robbinsii	6.7-9.8	*Phragmites communis*	6.5-9.8

continued

Species	pH Range	Species	pH Range
Potamogeton dimorphus	6.7-9.8	Pontederia cordata	6.0-9.8
Potamogeton zosterifolius	6.7-9.8	Potentilla palustris	6.1-9.8
Ranunculus longirostris	7.5-9.8	Sagittaria latifolia	5.8-9.8
Scirpus subterminalis	6.3-9.8	Sagittaria heterophylla	6.4-9.8
Utricularia gibba	6.5	Scirpus acutus	6.7-9.8
Utricularia minor	6.5	Scirpus americanus	7.5-9.8
Utricularia purpurea	6.5	Scirpus fluviatilis	7.9-8.5
Utricularia vulgaris	6.5-9.8	Scirpus rubrotinctus	6.4-8.4
Brasenia schreberi	5.6-9.8	Scirpus torreyi	6.7-9.8
Castalia tuberosa	5.6-9.8	Scirpus validus	7.1-9.3
Nymphozanthus microphyllus	6.5-9.6	Sparganium americanum	7.5-9.8
Nymphozanthus rubrodiscus	6.0-9.8	Sparganium chlorocarpum	7.7-9.8
Nymphozanthus variegatus	5.8-9.8	Sparganium eurycarpum	6.7-8.4
Sparganium angustifolium	6.0-9.8	Typha latifolia	5.8-9.8
Sparganium fluctuans	6.4-9.8	Zizania aquatica	7.7-9.8
Vallisneria americana	7.5-9.8	Spirodela polyrhiza	7.4-7.9
Lemna perpusilla	7.5-7.9	Acorus calamus	7.7
Lemna trisulca	7.4-9.3	Calla palustris	7.7-9.8
Riccia fluitans	7.4-8.1	Carex comosa	7.4-9.8
		Decodon verticillatus	7.5-9.8

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This series of Bulletins gives taxonomic, habitat and distributional data on the wetland plants of New England. Included are mean and range data for alkalinity and pH of New England waters where the species are found. These pH and alkalinity data are collected in the table below.

Species	pH		Alkalinity (mg/L)	
	mean	range	mean	range
Typha latifolia	7.4	5.4-9.8	39.2	1.5-170.0
Typha angustifolia	7.2	6.1-8.2	56.0	7.5-137.5
Sparganium eurycarpum	7.4	6.7-8.2	47.7	17.0-108.5
Sparganium minimum	7.3	6.5-8.5	35.4	3.5-69.5
Sparganium fluctuans	6.9	6.1-7.9	13.5	3.0-49.5
Sparganium androcladum	6.8	6.8	15.0	15.0
Sparganium americanum	6.9	5.3-9.8	17.7	0.5-123.5
Sparganium angustifolium	7.2	6.5-9.5	26.1	2.5-103.5
Sparganium chlorocarpum	6.9	6.2-7.8	17.2	3.0-112.5
Alisma graminium	7.5	7.5	47.5	47.5
Alisma plantago-aquatica	7.0-7.3	6.5-8.4	30.5-69.5	11.0-290.0
Sagittaria subulata	6.7	6.7-6.8	20.3	15.0-35.0
Sagittaria teres	5.2	4.5-5.9	5.5	4.0-7.0
Sagittaria graminea	7.0	6.4-8.4	18.7	3.0-111.5
Sagittaria rigida	7.4	6.5-8.9	31.3	10.0-57.5
Sagittaria latifolia	6.9	5.0-9.2	26.4	1.5-290.0
Sagittaria cuneata	7.4	6.8-8.9	36.7	5.0-127.0
Butomus umbellatus	7.5	7.3-7.6	95.8	55.0-153.0
Vallisneria americana	7.4	5.8-10.2	33.5	3.0-115.5
Elodea nuttallii	6.9	5.6-8.9	23.5	5.0-108.5
Elodea canadensis	7.6	6.5-10.2	67.7	10.0-153.0
Peltandra virginica	7.0	5.6-9.5	15.8	1.0-89.0
Wolffia columbiana	7.4	6.8-7.9	48.0	12.0-107.0
Wolffia borealis	7.3	6.8-7.9	34.4	12.0-107.0
Spiroela polyrhiza	7.1	5.7-7.9	43.5	3.5-111.5
Lemna trisulca	7.3	7.0-7.4	60.4	26.0-153.0
Lemna minor	7.2	6.1-9.5	36.2	2.5-127.0
Eriocaulon septangulare	6.9	5.8-8.3	9.6	2.5-29.5
Pontedaria cordata	7.0	5.0-8.9	20.3	2.5-111.5
Heteranthera dubia	7.8	6.8-9.5	63.5	19.5-153.0
Trapa natans	7.1	6.7-8.2	37.7	12.0-127.5
Myriophyllum tenellum	6.6	5.9-7.2	7.2	3.0-19.5
Myriophyllum humile	6.3	5.8-7.0	7.0	2.5-13.0
Myriophyllum farwellii	6.6	6.1-7.1	7.2	3.0-9.5
Myriophyllum alterniflorum	7.2	6.5-8.0	21.9	5.0-78.0
Myriophyllum verticillatum	6.9	6.5-7.8	18.0	5.0-39.0
Myriophyllum heterophyllum	6.5	6.2-8.9	12.5	3.0-33.0
Myriophyllum spicatum	7.8	6.7-10.2	60.0	12.0-102.5
Myriophyllum exalbescens	7.8	6.8-9.8	57.4	13.5-123.5
Proserpinaca palustris	6.5	5.4-7.3	13.0	2.5-100.0
Hippuris vulgaris	7.0	6.5-7.3	24.6	12.0-49.5
Cabomba caroliniana	6.5	5.9-6.8	15.8	3.5-35.0
Brasenia schreberi	6.6	5.7-9.5	15.9	2.5-111.5
Nymphaea odorata	7.0	5.3-9.5	25.0	2.0-141.5
Nymphaea tuberosa	7.6	6.8-8.6	59.0	10.0-153.0
Nymphaea tetragona	7.1	7.0-7.3	24.8	13.5-40.0
Nuphar pumila	7.4	6.5-9.5	36.1	3.5-103.5
Ceratophyllum demersum	7.3	5.9-8.9	51.6	5.5-151.0

continued

Species	pH		Alkalinity (mg/L)	
	mean	range	mean	range
Ceratophyllum echinatum	6.8	5.7-7.8	25.1	6.0-120.0
Utricularia intermedia	6.7	5.9-7.9	9.7	3.5-52.5
Utricularia radiata	6.6	5.6-7.3	7.8	1.0-33.0
Ulticularia purpurea	6.6	5.6-7.3	7.8	2.5-33.0
Ulticularia minor	6.9	6.0-8.1	9.6	3.0-33.5
Utricularia geminiscapa	6.7	3.5-8.6	24.6	5.4-69.5
Utricularia vulgaris	6.7	5.7-8.6	18.6	2.5-109.0
Utricularia gibba	6.7	5.8-8.6	15.6	3.0-69.5
Utricularia cornuta	6.4	5.6-6.9	3.7	1.0-7.0
Nuphar variegata	7.0	5.0-9.8	27.7	2.0-132.5

73. Spence, D.H.N. 1964. The Macrophytic Vegetation of Freshwater Lochs, Swamps and Associated Fens. In: J.H. Burnett, Editor. The Vegetation of Scotland. Oliver and Boyd, Edinb. Chapter 9, pp. 306-425.

This is an extensive analysis of what aquatic plants grow in Scottish lakes and what environmental factors are associated with each association of aquatic plants. Little specific data is given on the presence of individual species, as opposed to associations, in specific lakes with known pH and alkalinity data. However, it was possible to extract the data in the following table using tables 36,43,46,47,52 and 54 in this reference.

Species	pH range	Alkalinity range (mg/l)
Chara globularis	8.9	5.9
Chara aspera	7.8-9.3	37-135.4
Chara delicatula	8.7-9.3	61.2-135.4
Chara papillosum	8.7	135.4
Nitella translucens	7.0-8.0	2-57
Nitella opaca	7.3-7.8	37-44.4
Fontinalis antipyretica	7.0-9.5	2-76
Drepunocladus revolvens	6.6-8.0	57
Drepunocladus exannulatus	6.0-7.3	0
Sphagnum squarrosum	8.7	89.6
Sphagnum cuspidatum	6.0-7.3	0
Sphagnum palustre	6.6-7.3	0
Sphagnum papillosum	6.0	
Sphagnum plumulosum	6.0-6.6	
Sphagnum subsecundum	6.0-7.3	0
Scorpidium scorpioides	7.2	
Campylium stellatum	7.2	
Cratoneuron commutatum	7.3	
Isoetes lacustris	7.0	2
Equisetum fluviatile	8.7	89.6
Potamogeton perfoliatus	7.0-9.5	2-78
Potamogeton pectinatus	8.5-9.5	61.2-135.4
Potamogeton berchtoldii	7.0-8.0	2-57
Potanogeton crispus	7.0-8.0	2-13.6
Potamogeton obtusifolius	7.0	2-13.6
Potamogeton praelongus	6.8-8.8	20-135.4
Potamogeton lucens	7.3-8.5	37
Potamogeton gramineus	8.0-8.7	57-135.4
Potamogeton natans	7.0-8.7	12-135.4
Potamogeton alpinus	7.0	12
Potamogeton pusillus	7.8	37
Potamogeton polygonifolius	6.0-7.3	0
Sparganium minimum	7.7-8.0	44.4-57
Elodea canadensis	7.0-8.5	12-13.6
Lemna minor	8.7	89.6

continued

Species	pH range	Alkalinity range (mg/l)
Eleocharis quinqueflora	6.0-8.0	57
Agrostis canina	8.7	89.6
Agrostis stolonifera	72	
Agrostis tenius	6.0-7.3	0
Festuca vivipara	6.0-7.3	
Holcus lanatum	7.3	
Luzula campestris	7.3	
Eriophorum angustifolium	6.0-7.3	0
Carex echinata	6.0-7.3	0
Carex demissa	6.0-8.0	57
Carex dioca	7.2	
Carex nigra	6.0-8.7	0-89.6
Carex panicea	6.0-8.0	57
Carex pulicaris	6.0-7.3	
Carex rostrata	7.3-8.7	57-89.6
Carex vesicaria	8.7	89.6
Myriophyllum alterniflorium	7.0-7.8	2-37
Myriophyllum spicatum	8.5-8.7	78-135.4
Utricularia vulgaris	7.0-8.0	2-57
Utricularia intermedia	7.2	
Ceratophyllum demersum	8.5	
Littorela uniflora	7.0-9.3	12-135.4
Lobelia dortmanna	7.0-7.3	12-37
Callitriche stagnalis	7.7	44.4
Callitriche hermaphroditica	7.7-7.8	37-44.4
Ranunculus aquatilis	7.0	13
Ranunculus trichophyllus	7.8	37
Ranunculus flammula	6.0-7.3	0
Veronica scutellata	7.2	
Cicuta virosa	8.7	89.6
Menyanthes trifoliata	7.3-8.7	89.6
Myosotis pulustris	7.2	
Potentilla palustris	7.3-8.7	89.6
Cardamine pratense	7.3	
Hydrocotyle vulgaris	7.3	
Montia fontana	7.3	
Juncus fluitans	7.0-7.3	12-37
Juncus articulatus	6.0-8.0	57
Juncus bulbosus	6.0-7.3	0

74. Reynolds, J.D. and S.C.P. Reynolds. 1975. Aquatic Angiosperms of Some British Columbia Saline Lakes. Syesis 8:291-295.

A study of 12 similar nearby Chilcotin lakes was carried out to document aquatic plants and correlate their distribution with pH, conductivity and the major anions and cations present. These were all lakes lacking in permanent inflow and outflow steams and they reach high conductivity levels by late in the growing season since at the 950 meter elevation of the dry parkland in which they were located the mean yearly precipitation in only 35 cm and mean July temperatures are 25°C. Temperatures fluctuated above 20°C from May to early September, reaching a maximum of 26.7°C in the shallow lakes with mean depths in the 0.5-2.8 m range and maximum depths up to 6.5 in one lake but usually around 2-3 meters. In temperate regions there is a marked correlation of plant distribution with the dominent anion. Euryhaline species can tolerate much higher salinities in sulphate lakes than in carbonate/bicarbonate lakes.

Species	pH range	conductivity range*
Scirpus lacustis (*validus*)	7.8-10.5	600-12000
Juncus balticus	7.8-10.5	600-12000
Polygonum amphibium	7.8-9.7	600-3000
Myriophyllum exalbescens	7.8-10.5	600-3000
Potamogeton pectinatus	7.8-9.7	600-3000
Ruppia maritima	8.4-10.5	1500-3000
Zannichellia palustris	8.4-10.5	700-1500
Potamogeton pusillus (*foliosus*?)	6.9-9.7	40-800
Sagittaria cuneata	6.9-9.0	40-800
Hippuris vulgaris	9.3	700
Potamogeton natans	6.9	40
Sparganium angustifolium (*emersum*)	6.9	40
Utricularia vulgaris	6.9	40
Callitriche (*verna?*)	6.9	40
Ceratophyllum demersum	7.8-9.7	600-800
Potamogeton perfoliatus (*richardsonii*?)	9.0-9.3	700-800

* micro ohms / cm at 25°C.

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DISCUSSION OF THE DATA

Inspection of the tables of alkalinity and pH ranges shows that aquatic plants have a very wide latitude in pH and alkalinity values over which they can grow. Data is limited for alkalinity but some species show a range over orders of magnitude. Plants have been documented to grow over the range 0-448 mg/l. For some species a great deal of pH data is available. The range of pH values over which some species can survive is quite remarkable; a minimum of pH 2.0 and a maximum of pH 10.6 have been recorded for aquatic plants. For any one species the range may reach 7 orders of magnitude change in the hydrogen ion concentration, pH 3.0 to pH 10.0, in the floating duckweed species *Spirodela polyrhiza* and pH 2.9 to pH 10.2, in the submerged milfoil species *Myriophyllum spicatum*. It often exceeds 6 orders of magnitude as shown in the table below. The emergent *Eleocharis sellowiana* can grow at pH 2.0 and the floating *Eichhornia crassipes*, the water hyacinth, may be found at pH 10.6. These

Aquatic Plants found over pH ranges exceeding 6 orders of magnitude

Species	habit	differential	min.	max.
Myriophyllum spicatum	*	7.3	2.9	10.2
Spirodela polyrhiza	-	7.0	3.0	10.0
Eleocharis acicularis	•	6.9	2.9	9.8
Sparganium eurycarpum	•	6.9	3.1	10.0
Polygonum amphibium	x	6.8	3.4	10.2
Scirpus americanus	•	6.8	3.5	10.3
Sagittaria latifolia	•	6.7	3.1	10.2
Sagittaria gramineum	•	6.7	3.1	9.8
Typha latifolia	•	6.7	3.5	10.2
Eichhornia crassipes	-	6.6	4.0	10.6
Polygonum hydropiperoides	•	6.5	3.5	10.0

continued

Species	habit	differential	min.	max.
Brasenia shreberi	x	6.5	3.5	10.0
Ranunculus flammula	*	6.5	3.5	10.2
Utricularia vulgaris	*	6.5	3.7	10.2
Sparganium angustifolium	.	6.3	3.7	10.0
Menyanthes trifoliata	.	6.3	3.7	10.0
Potamogeton gramineus	x	6.3	3.7	10.0
Potamogeton natans	x	6.3	3.7	10.0
Scirpus lacustris	.	6.3	4.2	10.5
Ludwigia palustris	*	6.2	3.1	9.3
Potamogeton epihydrus	x	6.1	3.1	9.2
Potamogeton nodosus	x	6.1	3.1	9.2
Scirpus subterminalis	x	6.1	3.7	9.8
Sparganium minimum	x	6.1	3.7	9.8
Lobelia dortmanna	*	6.1	3.7	9.8
Eleocharis palustris	.	6.1	4.1	10.2
Potentilla palustris	.	6.1	4.3	10.4
Wolffia arrhiza	-	6.0	4.0	10.0
Pistia stratiotes	-	6.0	4.0	10.0

- free floating species. (4)
* submerged species (except flowers). (5)
x rooted, but with leaves floating on the surface. (8)
. emergent. (12)

extreme values are for survival in the short term and few species could reproduce and maintain a population permanently if pH's remained at these extremes all the time. Similarly there is selection pressure for races with pH tolerance to grow under these extreme conditions. Plants presently growing in alkaline conditions would be unlikely to make the transition to to extremely low pH conditions. The best growth for most species is circumneutral or slightly alkaline conditions since most species use dissolved HCO_3^- in photosynthesis. Exceptions are a few species which use dissolved CO_2 and therefore are restricted to acidic conditions and the emergent and floating-leaf plants which may use atmospheric CO_2. It is noteworthy that of the 29 world-wide species in this table which show at least 6 orders of magnitude tolerance to hydrogen ion concentration, 12 of them are found on a list of aquatic plants with high frequencies of occurrence in British Columbia lakes (over 10%). The reason for their wide distribution and high frequency of occurrence is likely their high tolerance for a wide range of environmental conditions, including pH. Optimal growth pH values were given for some plants under experimental conditions. These values were 6.2 for Lemna minor, 7.0 for Spirodela oligorrhiza, 5.0 for Wolffia arrhiza and 7.0 for Pistia stratiotes. Very little of this kind of experimental work is reported in the literature on aquatic plants. A long term, low pH pulse of 3.2 was reported in a stream normally at pH 7.4. A number of species were not able to adapt to this low pH value and disappeared from the aquatic flora. These species included Callitriche stagnalis, Ceratophyllum demersum, Elodea canadensis, Luronium natans and Hydrocharis morus-ranae. This low pH pulse of 3.2 is indeed below the lowest reported pH at which any of these species were found growing in any other reference.

Totally submerged plants rely on dissolved carbon in the water as a requirement for photosynthesis. This exists as CO_2, HCO_3^- or $CO_3^=$, depending upon the pH, as indicated in Figure 1. The availability of HCO_3^-, which is the main form of carbon used by most plants drops to 10% at pH 5.4, and 30% at pH 6.0, of its peak value at pH 8.4. Since diffusion in water is slow compared to that in air this puts severe restraint on aquatic plants being able to grow as the pH drops below the 5 or 6 level, unless, as a few are, they are able to utilize free CO_2. Some plants, especially those adapted for low pH conditions, have responded by developing efficient scavenging mechanisms for the carbon released in respiration. This carbon is recycled into photosynthesis so that only a limited amount of supplemental carbon needs to be picked up from the environment. Three mosses, *Drepanocladus exannulatus*, *D. fluitans* and *Sphagnum cuspidatum* and 2 dicotyledons, *Myriophyllum farwellii* and *Utricularia purpurea* all have maximum pH's below the level where CO_2 is no longer available. They may be unable to utilize HCO_3^- and may have to rely on CO_2 and thus be confined to low pH waters.

Lobelia dortmanna and probably also *Littorella uniflora* and *Isoetes* spp. have large root surface areas and are able to utilize CO_2 found in sediments and interstitial water for photosynthesis. They absorb CO_2 in their roots and translocate it to the leaves for photosynthesis and are thus largely independent of carbon levels in the water column. These plants are often found in sandy or gravelly sediments low in organic matter and subject to groundwater infiltration, and in softwater oligotrophic conditions at high latitudes where pH's are low. They are also found over a wide range of pH's, from the 3's to the 9's but it appears that the pH of the overlying water is not relevant to their growth; it is the availability of free CO_2 in the root zone that is important. The moss *Fontinalis antipyretica* is another presumed Co_2 user, unable to utilize HCO_3^-. In analyses of the distribution of *Fontinalis* in British Columbia lakes it is found taht all the lakes have pH's below 8.4, in the location in which the *Fontinalis* is growing and at the season of active growth. Where general lake pH's were in excess of this value, *Fontinalis* was found to inhabit a microhabitat, such as groundwater inflow or a stream mouth zone where pH's were locally lowered and free CO_2 presumably present. *Fontinalis* is also often found attached to logs or rocks near the surface and as water levels drop in the summer, and pH's rise, *Fontinalis* becomes exposed and goes dormant until rising water levels from fall rains or spring snowmelt, with their lower pH water, inundate the plants again. Therefore, the report of *Fontinalis* growing in a lake whose midsummer pH has been measured to be above 8.4 does not prove that *Fontinalis* was physiologically active at that time or able to use the only available carbon source which is HCO_3. References concerning the form of carbon used by plants for photosynthesis which deal specifically with CO_2 plants at low pH's are not common. Some which are concerned with the above mentioned species of presumed CO_2^-only users, Fontinalis antipyretica, Littorella uniflora, Isoetes spp., Utricularia purpurea and Lobelia dortmanna are: Moeller, R.E. - 1978, Wium-Anderson, S. - 1971 and Nielson, E.S. - 1946.

Another factor which must be considered when determining the pH limits of aquatic plants is the sometimes very wide diurnal fluctuations in pH caused by the repiration/photosynthesis cycle of the plants themselves. This fluctuation, which may be as much as 3 pH units diurnally is most pronounced in midsummer when water temperatures are maximum and plant biomass is also at its peak. This leads to depletion of carbon by late afternoon and very high levels in the early morning, but these fluctuations may only be localized around the vegetated areas and not reflected by mid lake pH measurements made once during daylight hours, as is usual in such survey information. These conditions are most pronounced in shallow, warm, eutrophic lakes which tend to be alkaline or circumneutral and have most of their carbon in the HCO_3^- form. The plants must normally be capable of adjusting to these quite wide diurnal pH changes and therefore changes of this magnitude and in this pH range are not significant to plant survival. It is changes down below pH 5 or so where HCO_3^- is no longer available that are of concern for the elimination of many species of aquatic plants.

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CHARA CONTRARIA	7.7-8.4(33)
CHARA CORALLINA	5.3-9.1(23)
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CHARA PAPILLOSUM	8.7(73)
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CHARA TOMENTOSA	7.7-8.2(33),7.4(35)
CHARA VULGARIS	7.4-8.5(33),7.5-8.7(54)
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NITELLA GRACILIS	6.9-7.7(33),6.3-8.5(54)
NITELLA MUCRONATA	8.2-8.5(33),7.6-8.0(62),8.6(63),7.2(64)
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NITELLA TENUISSIMA	4.8-7.0(21),6.3-8.5(54)
NITELLA TRANSLUCENS	7.0-8.0(73)
NITELLA WAHLBERGIANA	6.2-7.3(41)
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TOLYPELLA INTRICATA	7.7-8.7(54)
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2. AQUATIC LIVERWORTS

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MARSUPELLA EMARGINATA	5.2-6.3(12)
NARDIA COMPRESSA	5.3-5.9(12)
RICCIA FLUITANS	6.5-8.8(25),7.4(37),6.2-7.3(41),6.5(45),6.2-7.8(59),
RICCIOCARPUS NATANS	5.6-9.2(25),7.4(37),6.2-7.3(41),6.5(45),6.7-9.1(59),6.3-8.9(70),7.4-8.1(71)
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SCAPANIA DENTATA	5.3-6.6(12)
SCAPANIA IRRIGUA	5.8(60)
SCAPANIA ULIGINOSA	5.3-5.7(12)
SCAPANIA UNDULATA	5.3-7.1(12)

3. AQUATIC MOSSES

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CALLIERGON GIGANTEUM	6.9(12),6.3-7.7(60)
CALLIERGON MEGALOPHYLLUM	6.7(30),7.4(37),6.2-7.3(41),5.6-7.8(60)
CALLIERGON RICHARDSONII	6.1-7.8(60)
CALLIERGON SARMENTOSUM	6.3(12)
CALLIERGON STRAMINEUM	5.7-7.1(60)
CALLIERGON TRIFARIUM	6.3-7.2(60)
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CAMPYLIUM STELLATUM	6.3-6.4(12),7.3-7.6(60),7.2(73)
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DICHELYMA FALCATUM	6.1-6.4(60)
DREPANOCLADUS	5.6-7.2(12),4.9(13),7.0-9.3(32),7.4(37),5.8-6.8(40),6.2-7.3(41),4.6-7.0(44),8.2(54),5.2-5.8(57,58),5.0-9.0(60),6.0-8.0(73)
DREPANOCLADUS ADUNCUS	6.3-7.0(12),7.4(37),6.2-7.3(41),6.1-7.6(60)
DREPANOCLADUS CAPILLIFOLIUS	7.4(37),5.8-9.0(60)
DREPANOCLADUS EXANNULATUS	5.6-7.2(12),4.9(13),6.7(30),5.8-6.8(40),6.2-7.3(41),5.2(57,58),5.0-7.8(60),6.0-7.3(73)
DREPANOCLADUS FLUITANS	5.7-7.0(12),4.6-7.0(44),5.2-5.8(57,58),4.8-6.8(60)
DREPANOCLADUS PROCERUS	4.8-9.0(60)
DREPANOCLADUS REVOLVENS	6.8-7.0(12),7.1-7.3(60),6.6-8.0(73)
DREPANOCLADUS SENDTERI	6.2-7.3(41)
DREPANOCLADUS TENUINERVIS	7.4(37),6.2-7.3(41),6.0-8.0(60)
DREPANOCLADUS TRICHOPHYLLUS	5.6-5.7(12),6.7(30),7.4(37),5.0-9.0(60)
DREPANOCLADUS TUNDRAE	7.4(37),6.4-7.8(60)
DREPANOCLADUS UNCINATUS	7.0-9.3(32)
FISSIDENS	6.3-7.2(12),7.3-7.8(60)
FISSIDENS ADIANTHOIDES	6.8-7.0(12)
FISSIDENS FONTANUM	7.3-7.8(60)
FISSIDENS OSMONDOIDES	6.3-7.2(12),7.2(60)
FONTINALIS	5.6-7.2(12),4.0-7.0(21),6.7(30),7.0-9.3(32),7.4(37),5.8-6.8(40),6.2-7.3(41),6.0-7.2(44),7.1-8.5(54),7.0-8.4(56),5.4-8.9(57,58),5.7-8.5(60),7.0-9.5(73)
FONTINALIS ANTIPYRETICA	5.6-7.2(12),5.9-8.5(25),6.7(30),7.0-9.3(32),7.4(37),6.2-7.3(41),7.1-8.5(54),7.0-8.4(56),5.4-8.9(57,58),5.7-8.5(60),7.0-9.5(73)
FONTINALIS DALECARLICA	5.7(12),5.7-7.5(60)
FONTINALIS HYPNOIDES	5.6-5.9(12),6.7(30),5.8-6.8(40),6.2-7.3(41),6.0-8.4(60)
FONTINALIS NOVAE-ANGLIAE	6.0-7.1(44)
FONTINALIS SQUAMOSA	5.6-7.1(12)
HYGROAMBLYSTEGIUM FLUVIATILE	6.2-7.3(41)
HYGROHYPNUM	5.7-7.1(12),6.2-7.3(41)
HYGROHYPNUM LURIDUM	6.9(12)
HYGROHYPNUM OCHRACEUM	5.7-7.1(12),6.2-7.3(41)
LEPIDODICTYUM	5.8-6.8(40),6.2-7.3(41),3.3-4.3(44),6.2-7.5(60)
LEPIDODICTYUM KOCHII	6.2-7.3(41)
LEPIDODICTYUM RIPARIUM	5.8-6.8(40),6.2-7.3(41),3.3-4.3(44),6.2-7.5(60)
POLYTRICHUM COMMUNE	4.2(44),6.8(60)
PLATYHYPNIDIUM RIPAROIDES	7.0-9.3(32),6.6-7.4(60)
SCORPIDIUM SCORPIOIDES	6.6-6.9(12),6.7(30),5.8-6.8(40),5.6-8.4(60),7.2(73)

SPHAGNUM 4.6-4.8(4),3.6-3.9(8),5.6-6.9(12),4.9(13),4.0-6.7(21), 3.4-5.8(57,58),4.4-7.4(60),4.8(66),6.0-8.7(73)
SPHAGNUM ANNULATUM 4.4-7.0(60)
SPHAGNUM AONGSTROEMII 5.5(60)
SPHAGNUM BALTICUM 6.3(60)
SPHAGNUM COMPACTUM 4.8-7.1(60)
SPHAGNUM CONTORTUM 6.8(60)
SPHAGNUM CUSPIDATUM 3.6-4.0(8),5.6-6.9(12),4.9(13),4.1-5.2(57,58), 6.0-7.3(73)
SPHAGNUM LINDBERGIA 5.0-5.4(60)
SPHAGNUM MAUUS 4.4-7.0(60)
SPHAGNUM PALUSTRE 6.6-7.3(73)
SPHAGNUM PAPILLOSUM 4.4-6.2(60),6.0(73)
SPHAGNUM PARVIFOLIUM 5.8-6.8(40)
SPHAGNUM PLATYPHYLLUM 4.9-7.4(60)
SPHAGNUM PLUMULOSUM 6.0-6.6(73)
SPHAGNUM PULCHRUM 6.4(12)
SPHAGNUM PYLAESII 4.9(13)
SPHAGNUM RIPARIUM 5.8-6.8(40),4.8-7.4(60)
SPHAGNUM SQUARROSUM 6.6(12),8.7(73)
SPHAGNUM SUBSECUNDUM 5.6-6.9(12),3.4-5.8(57,58),6.0-7.3(73)

4. AQUATIC QUILLWORTS

ISOETES 4.6(4),4.9(13),4.3-7.0(21),3.7-9.2(25),6.7(30),6.9-7.1(36), 7.4(37),6.9-7.1(39),5.8-6.8(40),6.2-7.3(41),4.5-6.4(43), 4.1-7.9(44),6.0-6.9(46),5.3-6.0(47),6.5-8.2(53),6.3-8.5(54), 6.8-8.9(59),4.4-9.8(60),5.1-7.4(61),7.0-8.0(67),4.9-8.3(70), 5.6-9.8(71),7.0(73)
ISOETES BRAUNII 7.0-8.0(67)
ISOETES ECHINOSPORA 6.7(30),7.4(37),6.0-6.9(46),5.3(47),6.3-8.5(54), 5.0-9.8(60),5.7-8.3(70)
ISOETES ENGELMANNII 5.1-7.4(61)
ISOETES JAPONICA 6.8-8.9(59)
ISOETES LACUSTRIS 4.6(4),6.7(30),6.9-7.1(36),6.9-7.1(39), 5.8-6.8(40),4.5-6.4(43),6.0-6.9(46),5.3-6.0(47), 6.5-8.2(53),4.9-8.6(60),4.9-7.9(70),7.0(73)
ISOETES MURICATA 4.9(13),4.1-7.9(44)
ISOETES RIPARIA 6.0-7.4(44)
ISOETES SETACEA 6.2-7.3(41)

5. AQUATIC HORSETAILS

EQUISETUM 5.6-10.2(25),6.7(30),7.0-9.3(32),5.9-7.1(34),6.9-7.1(36), 7.4(37),6.9-7.1(39),6.2-7.3(41),6.5(45),6.0-6.9(46), 4.2-5.3(47),6.5-8.2(53),5.4-9.0(57,58),5.6-10.4(60), 6.8-8.8(67),4.9-8.9(70),4.9-8.9(70).6.4-9.8(71),8.7(73)
EQUISETUM FLUVIATILE 5.6-10.2(25),6.7(30),7.0-9.3(32),5.9-7.1(34), 6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41), 6.5(45),6.0-6.9(46),4.2-5.3(47),6.5-8.2(53), 5.4-9.0(57,58),5.6-10.4(60),6.8-8.8(67),8.7(73)
EQUISETUM PALUSTRE 5.6-9.2(25)

6. AQUATIC FERNS

AZOLLA	6.5-8.2(25),6.1-7.2(61)
AZOLLA CAROLINIANA	6.1-7.2(61)
AZOLLA FILICULOIDES	6.5-8.2(25)
MARSILEA	5.7-8.7(25),6.8-7.6(29)
MARSILEA QUADRIFOLIA	6.8-7.6(29)
MARSILEA VESTITA	5.7-8.7(25)
SALVINIA	5.2(14),6.8-9.5(14),6.8-7.6(29),6.0-7.7(59)
SALVINIA AURICULATA	5.2(14),6.8-9.5(14)
SALVINIA NATANS	6.0-7.7(59)
SALVINIA NYMPHELLULA	6.8-7.6(29)

7. AQUATIC FLOWERING PLANTS

MONOCOTYLEDONS

ACORUS CALAMUS	7.4(6),6.5-8.2(25),7.8-8.9(57,58),5.7-7.2(61), 7.3-8.8(67),6.2-9.0(70),7.7(71)
AGROSTIS	7.4(37),7.7-8.0(57,58),6.0-8.7(73)
AGROSTIS CANINA	7.4(37),8.7(73)
AGROSTIS STOLONIFERA	7.7-8.0(57,58),7.2(73)
AGROSTIS TENUIS	6.0-7.3(73)
ALISMA	7.4(6),5.6-10.2(25),6.7(30),5.9-7.1(34),7.4(37),6.2-7.3(41), 6.0-6.9(46),4.2-5.3(47),5.4-9.2(57,58),6.6-7.8(59), 6.1-8.7(60),6.2-7.5(61),7.0-8.8(67),5.7-8.9(70),6.5-8.4(72)
ALISMA CANALICULATUM	6.6-7.8(59)
ALISMA GRAMINEUM	6.5-8.9(25),7.5(72)
ALISMA PLANTAGO-AQUATICA	7.4(6),5.6-10.2(25),6.7(30),5.9-7.1(34), 7.4(37),6.2-7.3(41),6.0-6.9(46), 4.2-5.3(47),5.4-9.2(57,58),6.1-8.7(60), 7.0-8.8(67),5.7-8.9(70),6.2-7.5(71), 6.5-8.4(72)
ALOPECURIS	7.0-9.3(32),7.4(37),6.2-7.3(41),6.0-6.9(46),5.2-8.6(60), 6.4-7.1(61),6.4-7.1(70)
ALOPECURIS AEQUALIS	7.0-9.3(32),7.4(37),6.2-7.3(41),6.0-6.9(46), 5.2-8.6(60),6.4-7.1(70)
ALOPECURIS CAROLINIANUS	6.4-7.1(61)
ANEILEMA KEISAK	5.3-7.6(61)
BLYXA	7.0(59)
BLYXA ECHINOSPORA	7.0(59)
BLYXA JAPONICA	7.0(59)
BUTOMUS UMBELLATUS	6.2-7.3(42),6.5(45),7.0-8.9(57,58),6.0-7.6(60), 6.3-8.9(60),7.3-7.6(72)
CALDESIA RENIFORMIS	6.6-8.9(59)
CALLA PALUSTRIS	5.2-6.4(22),6.5-9.0(25),7.4(37),6.2-7.3(41),6.5(45), 6.0-8.5(60),6.3-8.8(70),7.7-9.8(71)
CALTHA PALUSTRIS	7.0-9.3(32),6.0-9.4(60)
CAREX	6.7(30),7.0-9.3(32),5.9-7.1(34),6.9-7.1(36),7.4(37), 6.2-7.3(41),6.0-6.9(46),6.5-8.2(53),5.2-8.3(57,58), 4.4-10.4(60),4.2-8.8(61),4.9-8.9(70),7.4-9.8(71),6.0-8.7(73)
CAREX ACUTA	6.0-6.9(46),5.8-8.6(60)
CAREX ALBOLUTESCENS	4.2-7.9(61)
CAREX ANNECTENS	6.8-6.9(61)
CAREX AQUATILIS	4.4-10.4(60)
CAREX CANESCENS	7.4(37)
CAREX COMOSA	6.3-6.4(61),7.4-9.8(71)
CAREX DEMISSA	6.0-8.0(73)
CAREX DIOCA	7.2(73)
CAREX ECHINATA	6.0-7.3(73)
CAREX ELATA	6.7(30),7.4(37),6.2-7.3(41)
CAREX HUDSONII	4.9-8.3(70)

CAREX LAEVIVAGINATA	7.1(61)
CAREX LASIOCARPA	6.7(30),6.0-7.1(34),5.8-6.8(40),6.5-8.2(53),6.4-8.3(57,58),4.9-9.8(60),4.9-8.3(70)
CAREX LEPTALEA	5.5-6.5(61)
CAREX LUPILINA	6.1-7.5(61)
CAREX LURIDA	4.9-8.4(61)
CAREX NIGRA	6.0-8.7(73)
CAREX PANICEA	6.0-8.0(73)
CAREX PSEUDOCYPERUS	6.3-8.9(70)
CAREX PULICARIS	6.0-7.3(73)
CAREX ROSTRATA	6.7(30),7.0-9.3(32),5.9-7.1(34),6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),6.0-6.9(46),6.5-8.2(53),5.2-8.0(57,58),4.4-10.4(60),5.7-8.3(70),7.3-8.7(73)
CAREX SCOPARIA	6.4-7.1(61)
CAREX STIPATA	6.0-6.8(61)
CAREX VESICARIA	5.9-7.1(34),7.4(37),6.2-7.3(41),6.0-6.9(46),5.2-7.6(60),8.7(73)
CAREX VULPINOIDEA	6.6-6.8961)
CLADIUM JAMAICENSE	6.5-8.4(61)
CYPERUS	6.8-7.6(29),4.0-8.6(61)
CYPERUS DIFFORMIS	6.8-7.6(29)
CYPERUS ERYTHRORHIZA	7.3(61)
CYPERUS FILICINUS	6.7(61)
CYPERUS ODORATUS	8.6(61)
CYPERUS POLYSTACHYOS	4.0-7.6(61)
CYPERUS PSEUDOVEGETUS	6.4-7.7(61)
CYPERUS STRIGOSUS	6.3-7.0(61)
CYPERUS TUBEROSUS	6.8-7.6(29)
DULICHIUM ARUNDINACEUM	5.6-10.0(25),47-7.5(61),5.8-9.8(71)
ECHINOCHLOA	6.8-7.8(24),4.7-9.3(61),3.0-8.6(65)
ECHINOCHLOA CRUSGALLI	4.7-7.3(61),3.0-8.5(65)
ECHINOCHLOA PYRAMIDALIS	6.8-7.6(29)
ECHINOCHLOA WALTERI	5.1-9.3(61)
ECHINODORUS CORDIFOLIUS	5.8-7.3(61)
EGERIA DENSA	6.8-7.2(25),6.4-9.2(50),8.8(59),6.0-8.4(61)
EICHHORNIA CRASSIPES	4.0(16),4.0-9.0(28),5.7-10.6(59),6.6(61),
ELEOCHARIS	4.9(13),2.0(14),4.3-7.0(21),5.6-10.2(25),6.7(30),6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),3.9-7.9(44),6.0-6.9(46),4.2-5.3(47),2.9-7.9(48),5.0-9.8(60),5.3-7.8(61),3.4-9.4(65),4.8(66),6.3-9.0(67),3.1-6.8(69),5.8-9.8(71),6.0-8.0(73)
ELEOCHARIS ACICULARIS	4.9(13),4.3-7.0(21),5.6-9.2(25),6.7(30),7.0-9.3(32),6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),3.9-7.9(44),6.0-6.9(46),4.9-5.3(47),2.9-7.9(48),6.4-8.3(57,58) 5.0-9.8(60),5.3-7.8(61),7.0-8.0(67),3.1-6.8(69),6.0-9.3(71)
ELEOCHARIS ALBIDA	6.8-8.6(61)
ELEOCHARIS BALDWINII	5.6-6.8(61)
ELEOCHARIS EQUISETOIDES	5.4(61)
ELEOCHARIS FLAVESCENS	4.0-8.5(61)
ELEOCHARIS MELANOCARPA	6.1(61)
ELEOCHARIS MICROCARPA	4.6-7.4(61)
ELEOCHARIS OBTUSA	4.1-8.7(61),3.4-9.4(65),3.1-6.4(69),
ELEOCHARIS PALUSTRIS	5.6-10.2(25),6.7(30),7.0-9.3(32),5.9-7.1(34),7.4(37),6.2-7.3(41),6.0-6.9(46),4.2-5.3(47),5.7-9.0(57,58),5.9-9.8(60),6.2-7.5(61),6.3-9.0(67),5.7-9.0(70),5.8-9.8(71)
ELEOCHARIS QUADRANGULATA	6.5-7.3(61)
ELEOCHARIS QUINQUEFOLIA	6.0-8.0(73)
ELEOCHARIS ROBBINSII	4.6(44),4.9(61),6.4-6.5(71)
ELEOCHARIS SELLOWIANA	2.0(14)
ELEOCHARIS TENUIS	6.1-7.0(61)

ELEOCHARIS TRICOSTATA	5.1-7.0(61)
ELEOCHARIS TUBERCULOSA	4.9-7.6(61)
ELEOCHARIS VIVIPARA	5.7-6.4(61)
ELODEA	7.4(6),7.0-10.0(11),5.6-10.0(25),7.4(37),6.2-7.3(41),6.5(45),6.0-6.9(46),4.2-6.0(47),6.3-9.4(50),6.9-8.7(54),7.0-8.4(56),6.0-9.0(57,58),6.6-9.4(59),6.6-7.9(61),6.3-8.9(70),7.3-9.8(71),5.6-10.2(72),7.0-8.5(73)
ELODEA CANADENSIS	7.4(6),7.0-10.0(11),5.6-10.0(25),7.4(37),6.2-7.3(41),6.4(45),6.0-6.9(46),4.2-6.0(47),6.9-8.7(54),7.0-8.4(56),6.0-9.0(57,58),6.6-6.9(61) 7.0-8.8(67),6.3-8.9(70),7.3-9.8(71),6.5-10.2(72),7.0-8.5(73)
ELODEA NUTTALLII	6.5-7.5(25),6.3-9.4(50),6.6-9.4(59),6.6-7.9(61),7.3-8.8(67),5.6-8.9(72)
ERIOCAULON	4.9(13),4.2-7.6(21),4.2-7.4(44),6.3-6.9(54),4.9-7.6(61),4.8(66),6.7-7.8(67),5.6-9.3(71),5.8-8.3(72)
ERIOCAULON COMPRESSUM	4.9-5.4(61)
ERIOCAULON DECANGULARE	4.9-7.6(61)
ERIOCAULON PELLUCIDUM	6.8(61)
ERIOCAULON SEPTANGULARE	4.9(13),4.2-7.6(21),4.2-7.4(44),6.3-6.9(54),4.8(66),6.7-7.8(67),5.6-9.3(71),5.8-8.3(72)
ERIOPHORUM	5.8-8.3(57,58),6.4(61),6.0-7.3(73)
ERIOPHORUM ANGUSTIFOLIUM	5.8-8.3(57,58),6.0-7.3(73)
ERIOPHORUM VIRGINICUM	6.4(61)
FLOSCOPA AFRICANA	6.8-7.6(29)
FIMBRISTYLIS SPADICEA	7.6(61)
FUIRENA	6.8-7.6(61),5.2-10.0(61)
FUIRENA PUMILA	10.0(61)
FUIRENA SQUARROSA	5.2-7.6(61)
FUIRENA UMBELLATA	6.8-7.6(29)
GLYCERIA	6.0-7.1(34),7.4(37),6.2-7.3(41),6.4(44),6.5(45),6.0-6.9(46) 4.2-5.3(47),5.2-8.9(57,58),6.3-8.6(61),6.8-8.8(67),5.7-8.7(70)
GLYCERIA BOREALIS	6.4(44),6.8-8.8(67)
GLYCERIA FLUITANS	6.0-7.1(34),7.4(37),6.0-6.9(46),4.2-5.3(47),5.2-8.3(57,58),5.7-8.2(70)
GLYCERIA GRANDIS	7.2-8.8(67)
GLYCERIA MAXIMA	6.2-7.3(41),6.5(45),6.3-8.9(57,58),6.5-8.7(70),
GLYCERIA MELICARIA	6.5(61)
GLYCERIA STRIATA	6.3-8.6(61)
HETERANTHERA	5.6-9.2(25),7.1-8.7(54),6.0-7.5(61),7.6-9.0(67),7.5-9.8(71),6.8-9.5(72)
HETERANTHERA DUBIA	5.6-9.2(25),7.1-8.7(54),7.6-9.0(67),7.5-9.8(71),6.8-9.5(72)
HETERANTHERA RENIFORMIS	6.0-7.5(61)
HYDRILLA VERTICILLATA	6.1-9.7(50),6.1-9.6(59)
HYDROCHARIS	7.4(6),6.2-7.3(41),6.5(45),6.0-6.9(46),6.7-9.2(50),7.2-9.3(59),6.3-8.9(70)
HYDROCHARIS DUBIA	6.7-9.2(50),7.2-9.3(59)
HYDROCHARIS MORSUS-RANAE	7.4(6),6.2-7.3(41),6.5(45),6.0-6.9(46),6.3-8.9(70)
HYDROCHLOA CAROLINIENSIS	6.1-6.8(61)
IRIS	7.4(6),6.0-10.0(25),7.4(37),6.2-7.3(41),6.0-6.9(46),4.2-5.3(47) 4.9-7.2(61),6.2-8.9(70)
IRIS PRISMATICA	5.0-5.1(61)
IRIS PSEUDACORUS	7.4(6),6.0-10.0(25),7.4(37),6.2-7.3(41),6.0-6.9(46) 4.2-5.3(47),6.2-8.9(70)
IRIS VIRGINICA	4.9-7.2(61)

JUNCUS	3.5-6.5(8),4.3-7.6(21),3.7-9.0(25),6.7(30),5.9-7.1(34),4.6-5.1(36),4.5-5.9(43),4.4-7.4(44),4.5-5.8(47),6.9(60),4.8-8.7(61),3.1-6.4(69),6.0-8.1(70),5.6-9.8(71),6.0-8.0(73),7.8-10.5(74)
JUNCUS ABORTIVUS	4.0-6.7(61)
JUNCUS ACUMINATUS	4.2-8.4(61)
JUNCUS ARTICULATUS	6.0-8.0(73)
JUNCUS BALTICUS	7.8-10.5(74)
JUNCUS BIFLORUS	6.0-7.2(61)
JUNCUS BRACHYCARPUS	7.0(61)
JUNCUS BREVICAUDATUS	6.6(61)
JUNCUS BUFONIUS	5.3(61)
JUNCUS BULBOSUS	3.5-6.5(8),6.7(30),5.9-7.1(34),4.6-5.1(36),4.5-5.9(43),4.5-5.8(47),6.9(60),6.0-7.3(73)
JUNCUS CANADENSIS	4.7-7.6(61)
JUNCUS CORIACEUS	5.0-8.7(61)
JUNCUS DEBILIS	4.2-7.0(61)
JUNCUS DIFFUSISSIMUS	6.0-7.7(61)
JUNCUS EFFUSUS	4.7-8.4(61),3.1-6.4(69)
JUNCUS ELLIOTTII	5.6(61)
JUNCUS FLUITANS	7.0-7.3(73)
JUNCUS GYMNOCARPUS	5.5-7.0(61)
JUNCUS MARGINATUS	6.0-8.7(61)
JUNCUS MEGALOCEPHALUS	8.1(61)
JUNCUS MILITARIS	4.3-7.6(21),6.8(44)
JUNCUS PELOCARPUS	4.4-7.6(21),4.4-7.4(44),5.6-9.8(71)
JUNCUS REPENS	4.7-8.2(61)
JUNCUS ROEMERIANUS	6.6(61)
JUNCUS SCIRPOIDES	5.0-8.1(61)
JUNCUS SUBCAUDATUS	4.6-7.2(61)
JUNCUS SUPINIFORMIS	3.7-9.0(25)
JUNCUS SUPINUS	6.0-8.1(70)
LACHNOCAULON	4.5-5.8(61)
LACHNOCAULON ANCEPS	5.8(61)
LACHNOCAULON MINUS	4.5(61)
LEERSIA	5.0-8.6(61),6.7-7.8(65),7.2-9.0(67)
LEERSIA HEXANDRA	5.0-5.7(61)
LEERSIA ORYZOIDES	5.1-7.9(61),6.7-7.8(65),7.2-9.0(67)
LEERSIA VIRGINICA	8.6(61)
LEMNA	4.0-10.0(1),4.1-7.1(17),7.7-8.2(24),5.6-10.2(25),4.4-7.9(27),4.2-6.2(31),7.0-9.3(32),6.0-7.1(34),7.4(37),6.2-7.3(41),6.8-8.2(42),6.5(45),6.0-6.9(46),4.2(47),7.6-8.2(52),5.2-9.2(57,58),6.4-9.6(59),6.3-9.8(60),4.5-7.3(61),6.3-9.0(67),5.7-9.0(68),6.2-8.9(70),7.4-7.9(71),6.1-9.5(72),8.7(73)
LEMNA CYCLOSTASA	5.2-7.8(27)
LEMNA GIBBA	6.4-6.7(61)
LEMNA MINIMA	7.2-7.5(59)
LEMNA MINOR	4.0-10.0(1),5.6-10.2(25),4.5-7.5(27),4.2-6.2(31),7.0-9.3(32),6.0-7.1(34),7.4(37),6.2-7.3(41),6.8-8.2(42),6.5(45),6.0-6.9(46),4.2(47),5.2-9.2(57,58),6.6-9.3(59),7.2-9.8(60),6.3-9.0(67),5.7-9.0(68),6.2-8.9(70),6.1-9.5(72),8.7(73)
LEMNA PAUCICOSTATA	4.1-7.1(17),6.4-9.6(59)
LEMNA PERPUSILLA	7.7-8.2(24),7.6-8.2(52),4.5-7.2(61),7.5-7.9(71)
LEMNA TRISULCA	6.0-10.0(25),4.6-7.5(27),5.4-9.1(57,58),6.3-9.8(60),7.2-8.8(67),6.2-8.9(70),7.4-9.3(71),7.0-7.4(72)
LEMNA VALDIVIANA	6.8-7.4(59),5.2-7.3(61)
LILAEA SCILLOIDES	6.5-7.5(25)
LIMNOBIUM SPONGIA	3.5-5.9(20),6.0-6.9(61)
LURONIUM NATANS	7.4(6)
MARISCUS ALTERNIFLORUS	6.8-7.6(29)

MAYACA	5.0-6.5(61)
MAYACA AUBLETII	5.0-6.5(61)
MAYACA FLUVIATILIS	5.6-5.7(61)
MENYANTHES TRIFOLIATA	7.4(6),4.6-6.9(22),3.7-10.0(25),5.9-7.1(34),7.4(37),5.8-6.8(40),5.2-9.1(57,58),4.4-9.6(60),4.9-8.3(70),7.3-8.7(73)
MONOCHORIA	6.5-6.6(59)
MONOCHORIA KORSAKOWII	6.5(59)
MONOCHORIA VAGINALIS	6.6(59)
NAJAS	7.0-8.8(19),5.6-10.0(25),7.4(35),7.4(44),6.6-9.2(50),7.6-8.2(52),6.5-8.7(54),6.4-9.4(59),7.5(65),7.2-9.0(67),7.4-9.8(68),7.5-9.8(71)
NAJAS FLEXILIS	7.0-8.8(19),5.6-10.0(25),7.4(44),6.5-8.5(54)7.5(65),7.2-9.0(67),7.4-9.8(67),7.4-9.8(68),7.5-9.8(71)
NAJAS FOEVOLATA	6.9-7.8(59)
NAJAS GRACILLIMA	6.2-8.3(61)
NAJAS GRAMINEA	6.4-9.2(59)
NAJAS GUADALUPENSIS	7.7-8.7(54),6.6-10.0(61),7.2-8.6(67)
NAJAS JAPONICA	7.8(59)
NAJAS MARINA	7.4(35),6.6-9.2(50),6.9-8.9(59),8.2-9.0(67)
NAJAS MINOR	6.6-9.0(50),6.7-8.2(59)
NAJAS OGURAENSIS	6.5-9.4(59)
NAJAS TENUIFOLIA	7.6-8.2(52)
ORONTIUM AQUATICUM	4.7-7.3(61)
OTTELIA ALISMOIDES	6.9-7.8(59)
PANICUM	4.0-7.6(61)
PANICUM AGROSTOIDES	4.7-5.4(61)
PANICUM HEMITOMON	5.0-6.2(61)
PANICUM HIANS	4.0-7.6(61)
PANICUM STIPITATUM	5.3(61)
PANICUM VIRGATUM	6.5-7.6(61)
PASPALUM	3.5-5.9(20),6.0-9.3(61)
PASPALUM DISSECTUM	6.4(61)
PASPALUM DISTICHUM	6.0-7.7(61)
PASPALUM FLUITANS	3.5-5.9(20)
PASPALUM VAGINATUM	9.3(61)
PELTANDRA	5.1-7.6(61),5.6-9.5(72)
PELTANDRA SAGITTAEFOLIA	5.1-6.9(61)
PELTANDRA VIRGINICA	5.2-7.6(61),5.6-9.5(72)
PHALARIS ARUNDINACEA	5.2-8.7(60),7.3(61),7.3-8.8(67)
PHRAGMITES	7.4(6),6.7(30),7.0-9.3(32),5.9-7.1(34),4.6-5.1(35),6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),6.0-6.9(46),4.2-5.3(47),6.5-8.2(53),5.2-9.1(57,58),5.9-9.8(60),7.6-8.0(62),6.3-9.0(67),4.9-8.9(70),6.5-9.8(71)
PHRAGMITES COMMUNIS	7.4(6),6.7(30),7.0-9.3(32),5.9-7.1(34),4.6-5.1(35),6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),6.0-6.9(46),4.2-5.3(47),6.5-8.2(53),5.2-9.1(57,58),5.9-9.8(60),7.6-80(62),6.3-9.0(67),4.9-8.9(70),6.5-9.8(71)
PISTIA STRATIOTES	4.0-10.0(16),4.0-9.0(28),6.8-7.6(29)
POA ANNUA	7.4(37)
PONTEDERIA CORDATA	3.5-5.9(20),4.0-7.6(29),5.9-7.9(61),7.2-7.9(67),6.0-9.8(71),5.0-8.9(72)

POTAMOGETON	7.4(6),4.9(13),4.0-7.6(21),6.1-6.2(22),3.7-10.2(25), 5.4-8.9(26),6.7(30),7.0-9.3(32),5.9-7.1(34),7.4(35), 6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),5.2-6.4(43), 4.4-7.9(44),6.5(45),6.0-6.9(46),4.2-6.0(47), 4.8-10.9(51),6.5-8.2(53),6.5-8.7(54),5.2-8.9(57,58), 5.7-9.6(59),5.7-10.4(60),5.0-9.4(61),7.6-8.0(62), 6.4-9.4(65),4.8(66),6.3-9.1(67),6.6-10.2(68),3.1-6.4(69) 5.7-8.9(70),6.0-9.8(71),6.0-9.5(73),6.9-9.7(74)
POTAMOGETON ALPINUS	5.6-9.2(25),7.0-9.3(32),5.9-7.1(34),7.4(37), 6.2-7.3(41),6.5(45),4.2-6.0(47),6.9-8.7(51), 6.4-8.9(57,58),5.7-8.5(60),7.0-8.6(67), 6.8-7.8(68),5.7-8.9(70),7.0-8.5(73)
POTAMOGETON AMPLIFOLIUS	5.6-10.0(25),7.4(44),6.9-8.5(54),7.1-8.8(67) 6.7-9.8(71)
POTAMOGETON CONFERVOIDES	4.9(13),4.3-4.8(21),5.6(61),4.8(66),
POTAMOGETON CRISPUS	5.6-9.7(25),5.4-8.9(26),6.3-9.6(51),7.1-8.5(54), 7.0-8.5(57,58),8.4(59),7.6-8.4(67),6.5-8.6(70), 7.0-8.0(73)
POTAMOGETON CRISTATUS	6.4(51),6.5-7.8(59)
POTAMOGETON DISTINCTUS	6.1-10.9(51),5.7-9.3(59)
POTAMOGETON DIVERSIFOLIUS	8.3(25),5.0-9.1(61),7.7-9.4(65), 6.3-9.8(71)
POTAMOGETON EPIHYDRUS	4.0-7.6(21),3.7-8.8(25),6.0-7.4(44), 6.5-8.5(54),5.2-7.6(61),6.7-8.6(67), 6.6-9.2(68),3.1-6.2(69),6.4-9.2(71)
POTAMOGETON FOLIOSUS	6.5-9.0(25),6.1(61),6.4-8.6(65),7.2-8.8(67), 9.3(71)
POTAMOGETON FREYERI	5.4-7.0(26),4.8-9.2(51),6.4-7.0(59),
POTAMOGETON FRIESII	5.6-9.2(25),7.4(37),6.5-8.0(51),7.1-8.5(54), 6.8-9.8(60),7.7-8.8(67),6.7-9.5(68), 6.3-8.9(70)
POTAMOGETON GRAMINEUS	6.1-6.2(22),3.7-10.0(25),6.7(30),5.9-6.8(34), 6.2-7.3(41),7.4-7.9(44),6.0-6.9(46), 4.2-5.3(47),6.5-8.6(51),6.5-8.5(54), 6.4-8.9(57,58),5.7-9.4(60),7.0-8.8(67) 6.0-8.8(70),6.4-9.8(71),8.0-8.7(73)
POTAMOGETON ILLINOENSIS	5.6-9.2(25),7.1-8.7(54),7.4.9.4(61), 7.0-9.0(67)
POTAMOGETON MAACKIANUS	5.4-8.7(26),6.1-9.7(51),7.2-9.4(59)
POTAMOGETON MALAIAUS	6.8-9.2(51)
POTAMOGETON NATANS	4.3-5.6(21),3.7-10.0(25),6.7(30),5.9-7.1(34), 6.9-7.1(36),7.4(37),6.9-7.1(39),5.8-6.8(40), 6.2-7.3(41),5.2-6.4(43),6.0-6.9(46),4.2-5.3(47), 5.7-8.9(51),6.5-8.2(53),7.1-8.5(54), 5.2-8.3(57,58),5.7-9.4(60),7.6-8.0(62), 6.8-9.0(67),5.7-8.9(70),6.0-9.8(71),7.0-8.7(73), 6.9()74)
POTAMOGETON NODOSUS	6.3-9.2(25),8.2-8.5(54),6.7-6.8(61),6.4-7.7(65), 7.3-8.5(67),3.1-6.4(69)
POTAMOGETON OAKESIANUS	4.3-6.0(21)
POTAMOGETON OBTUSIFOLIUS	6.5-10.0(25),7.0-9.3(32),7.4(37),6.5(45), 6.4(51),6.4-8.9(57,58),6.6-8.7(60), 7.0-7.9(67),6.2-8.5(70),7.7-7.9(71),7.0(73)
POTAMOGETON OCTANDRUS	5.7-9.3(51),6.3-9.6(59)
POTAMOGETON OXYPHYLLUS	5.4-7.7(26),5.3-9.1(51),9.4(59)
POTAMOGETON PECTINATUS	5.0-10.2(25),7.4(35),4.4(44),7.1-8.7(51), 7.1-8.7(54),7.0-8.9(57,58),6.5-7.7(60), 6.6-6.7(61),6.3-9.2(67),6.6-10.2(68), 6.5-8.9(70),8.4-9.8(71),8.5-9.5(73), 7.8-9.7(74)

POTAMOGETON PERFOLIATUS	5.6-10.0(25),7.0-9.3(32),5.9-6.8(34),7.4(35) 6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41), 6.0-9.6(46),4.5-6.0(47),6.5-9.7(51), 6.9-8.7(54),6.0-8.9(57,58),6.0-10.4(60), 6.7-6.8(61),7.0-9.1(67),6.7-10.2(68), 5.7-8.3(70),7.4-9.8(71),7.0-9.5(73), 9.0-9.3(74)
POTAMOGETON POLYGONIFOLIUS	6.0-7.3(73)
POTAMOGETON PRAELONGUS	5.6-10.0(25),5.9-6.8(34),7.4(37),6.0-6.9(46), 7.1-7.8(51),7.1-8.5(54),5.8-8.5(60), 7.1-9.0(67),7.2-9.6(68),6.2-8.3(70), 7.3-9.8(71),6.8-8.8(73)
POTAMOGETON PULCHER	6.0-7.3(61)
POTAMOGETON PUSILLUS	4.8-6.8(21),5.6-10.2(25),6.7(30),7.0-9.3(32), 7.4(35),7.4(37),5.8-6.8(40),6.2-7.3(41), 6.4-7.0(44),6.0-6.9(46),4.2-5.3(47), 6.5-8.9(51),7.7-8.7(54),8.1-9.2(57,58), 5.7-9.8(60),5.9-8.4(61),7.0(65),7.0-8.8(67), 6.2-8.9(70),6.4-9.8(71),7.0-8.0(73), 6.9-9.7(74)
POTAMOGETON ROBBINSII	5.6-10.0(25),7.4(44),7.1-8.7(54),7.2-8.4(67), 8.0-9.8(68),6.7-9.8(71)
POTAMOGETON SPIRILLIS	6.0-7.4(44),7.0-8.3(67)
POTAMOGETON STRICTIFOLIUS	7.3-8.9(25),7.3-9.0(67)
POTAMOGETON ZOSTERIFORMIS	5.6-10.0(25),6.5(45),7.1-8.7(54), 6.9-9.0(67),6.2-8.4(70),6.7-9.0(71)
RHYNCHOSPORA	6.8-7.6(29),4.7-7.4(61)
RHYNCHOSPORA CORNICULATA	5.1-7.4(61)
RHYNCHOSPORA CORYMBOSA	6.8-7.6(29)
RHYNCHOSPORA MACROSTACHYA	4.7-7.3(61)
RHYNCHOSPORA TRACEYI	4.9-6.5(61)
RUPPIA MARITIMA	6.4-10.5(25),7.4(35),6.7-7.6(61),8.1-9.0(67), 7.7-9.4(68),8.4-10.5(74)
SACCIOLEPIS STRIATA	4.1-6.5(61)
SAGITTARIA	4.5-7.6(21),5.6-9.6(25),4.6-5.1(35),7.4(37),6.2-7.3(41), 4.4-7.4(44),6.5(45),6.0-6.9(46),4.2-5.8(47), 7.0-8.4(57,58),6.8-8.0(59),6.4-8.7(60),4.7-8.6(61), 6.3-9.0(67),6.2-9.3(68),3.1-6.8(69),5.7-8.8(70), 5.6-9.8(71),4.5-9.2(72),6.9-9.0(74)
SAGITTARIA CALYCINA	8.5(61)
SAGITTARIA CRISTATA	7.2-8.8(67)
SAGITTARIA CUNEATA	7.3-9.0(67),6.5-8.7(71),6.8-8.9(72),6.9-9.0(74)
SAGITTARIA ENGELMANNIANA	5.6-6.2(61)
SAGITTARIA FALCATA	6.1-8.6(61)
SAGITTARIA GRAMINEA	5.6-7.1(61),3.1-6.8(69),5.6-9.8(71),6.4-8.4(72)
SAGITTARIA HETEROPHYLLA	6.4-9.8(71)
SAGITTARIA LATIFOLIA	4.7-8.6(61),6.3-8.8(67),3.1-6.2(69), 5.8-9.8(71),5.0-9.2(72)
SAGITTARIA LONGIROSTRA	6.0-7.7(61)
SAGITTARIA NATANS	7.4(37),6.0-6.9(46),6.4-8.7(60),5.7-7.1(70)
SAGITTARIA RIGIDA	7.4-8.8(67),6.5-8.9(72)
SAGITTARIA SAGITTIFOLIA	4.6-5.1(35),7.4(37),6.2-7.3(41),6.5(45), 6.0-6.9(46),4.2-5.8(47),7.0-8.4(57,58), 5.7-8.8(70)
SAGITTARIA SUBULATA	7.1-7.2(61),6.7-6.8(72)
SAGITTARIA TERES	4.9-5.0(61),4.5-5.9(72)
SAGITTARIA TRIFOLIA	6.8-8.0(59)

SCIRPUS	4.9(13),3.5-5.9(20),6.0-6.5(22),7.7-8.2(24),3.7-10.5(25), 6.7(30),7.0-9.3(32),5.9-7.1(34),4.6-7.4(35),7.4(37), 6.2-7.3(41),6.5(45),6.0-6.9(46),4.2-5.3(47),6.5-8.2(53), 4.1-9.2(57,58),6.0-9.8(60),4.8-8.8(61),6.8-9.1(67), 4.9-9.0(70),6.3-9.8(71),7.8-10.5(74)
SCIRPUS AMERICANUS	3.5-5.9(20),6.6-10.3(25),5.1-8.5(61),7.4-8.9(67), 7.5-9.8(71)
SCIRPUS CALIFORNICUS	7.7-8.2(24)
SCIRPUS CESPITOSIS	6.0-6.5(22)
SCIRPUS CYPERINUS	4.8-8.4(61)
SCIRPUS DIVARICATUS	8.2(61)
SCIRPUS ETUBERCULATUS	4.8-7.4(61)
SCIRPUS EXPANSUS	5.8-7.4(61)
SCIRPUS FLUVIATILIS	8.1-8.7(25),7.0-9.1(67),7.9-8.5(71)
SCIRPUS GEORGIANUS	6.3-8.8(61)
SCIRPUS LACUSTRIS	5.0-10.5(25),6.7(30),7.0-9.3(32),5.9-7.1(34), 4.6-7.4(35),7.4(37),6.2-7.3(41),6.5(45), 6.0-6.9(46),4.2-5.3(47),6.5-8.2(53),6.0-9.1(57,58) 6.0-9.8(60),6.1-8.6(61),7.2-9.1(67),4.9-8.9(70), 6.7-9.8(71),7.8-10.5(74)
SCIRPUS MARITIMUS	7.8-9.2(57,58),8.4-9.0(67)
SCIRPUS MICROCARPUS	6.4-8.4(71)
SCIRPUS POLYPHYLLUS	6.7-7.4(61)
SCIRPUS PURSHIANUS	6.6-8.4(61)
SCIRPUS ROBUSTUS	6.3-8.3(61)
SCIRPUS SUBTERMINALIS	4.9(13),3.7-8.8(25),4.9-6.1(61),6.8-7.5(67), 6.3-9.8(71)
SCIRPUS SYLVATICUS	7.1(60)
SCIRPUS TORREYI	6.7-9.8(71)
SPARGANIUM	4.0-6.7(21),3.7-10.0(25),6.7(30),5.9-7.1(34),4.6-5.1(35), 6.9-7.1(36),7.4(37),6.9-7.1(39),5.8-6.8(40),6.2-7.3(41), 6.4-7.2(44),6.5(45),6.0-6.9(46),4.2-6.0(47),7.0-8.4(50), 3.4-8.9(57,58),4.9-9.8(60),4.8-7.3(61),7.0-8.8(67), 6.2-9.7(68),3.1-6.2(69),5.7-8.9(70),6.0-9.8(71), 5.3-9.8(72),7.7-8.0(73),6.9(74)
SPARGANIUM AFFINE	5.7-8.1(70)
SPARGANIUM ANDROCLADUM	6.8(72)
SPARGANIUM ANGUSTIFOLIUM	3.7-10.0(25),6.7(30),4.6-5.1(35), 6.9-7.1(36),7.4(37),5.8-6.8(40), 6.2-7.3(41),6.5(45),6.0-6.9(46),4.2-5.3(47), 4.1-8.9(57,58),4.9-9.6(60),6.6(61),7.3-8.4(67), 5.7-8.8(70),6.0-9.8(71),6.5-9.5(72),6.9(74)
SPARGANIUM ERECTUM	4.6-5.1(35),6.2-7.3(41),6.5(45),4.2(47) 7.0-8.4(56)
SPARGANIUM EURYCARPUM	5.6-10.0(25),5.9-7.1(34),7.0-8.9(57,58), 4.8-7.3(61),7.2-8.8(67),3.1-6.2(69), 7.5-9.8(71),5.3-9.8(72)
SPARGANIUM FLUCTUANS	5.6-7.4(25),6.4-7.2(44),7.0-7.3(67),6.4-9.8(71) 6.1-7.9(72)
SPARGANIUM FRIESII	6.7(30),6.9-7.1(36),7.4(37),6.9-7.1(39), 5.8-6.8(40),6.2-7.3(41),6.5(45),6.0-6.9(46), 4.9-6.0(47),5.6-8.4(60),5.7-8.1(70)
SPARGANIUM MINIMUM	3.7-9.5(25),6.0-7.1(34),4.6-5.1(35),7.4(37), 6.2-7.3(41),4.2-5.3(47),6.2-9.8(60),5.7-7.7(70), 6.5-8.5(72),7.7-8.0(73)
SPARTINA	4.9-7.7(61)
SPARTINA ALTERNIFLORA	7.2-7.6(61)
SPARTINA CYNOSUROIDES	4.9-7.7(61)
SPARTINA PATENS	6.6-7.2(61)
SPARTINA PECTINATUS	7.0(61)

SPIRODELA	3.0-10.0(1),5.6-10.0(25),5.5-8.0(27),6.2-7.3(41),6.5(45),6.0-6.9(46),6.4-9.2(50),6.2-8.9(57,58),6.3-10.1(59),6.0-8.2(61),6.3-8.8(67),6.6-9.2(68),6.3-8.9(70),7.4-7.9(71),5.7-7.9(72)
SPIRODELA OLIGORHIZA	3.0-10.0(1),7.3-9.4(59),6.1-6.8(61),
SPIRODELA POLYRHIZA	5.6-10.0(25),5.5-8.0(27),6.2-7.3(41),6.5(45),6.0-6.9(46),6.4-9.2(50),6.2-8.9(57,58),6.3-10.1(59),6.0-8.2(61),6.3-8.8(67),6.6-9.2(68),6.3-8.9(70),7.4-7.9(71),5.7-7.9(72)
STRATIOTES ALOIDES	7.4(6),6.2-7.3(41),6.0-6.9(46),7.0-8.4(57,58),6.1-8.2(60),7.6-8.0(62),6.3-8.9(70)
SYNGONANTHUS FLAVIDULUS	4.7(61)
TORULINIUM ODORATUM	6.8-7.6(29)
TYPHA	7.4(6),3.5-5.9(20),5.6-10.2(25),7.4(37),6.9-7.1(39),6.2-7.3(41),6.5(45),6.0-6.9(46),4.5(47),5.2-8.9(57,58),5.0-10.0(61),7.6-8.0(62),3.0-8.1(65),6.3-9.0(67),6.0-8.9(70),5.8-9.8(71),5.4-9.8(72)
TYPHA ANGUSTIFOLIA	7.4(6),6.2-7.3(41),6.1-8.1(61),7.6-8.0(62),4.5-7.6(65),3.1-6.8(69),6.0-8.9(70),6.1-8.2(72)
TYPHA DOMINGENSIS	6.7-8.6(61)
TYPHA LATIFOLIA	3.5-5.9(20),5.6-10.2(25),7.4(37),6.9-7.1(39),6.2-7.3(41),6.5(45),6.0-6.9(46),4.5(47),5.2-8.9(57,58),5.0-10.0(61),3.0-8.1(65),6.3-9.0(67),3.1-6.8(69),6.3-8.9(70),5.8-9.8(71),5.4-9.8(72)
VALLISNERIA	7.0-9.0(7),4.9(13),5.5-7.0(21),5.6-10.0(25),6.5-9.7(50),7.1-8.7(54),6.7-9.3(59),5.6-7.9(61),7.0-8.9(67),7.5-9.8(71),5.8-10.2(72)
VALLISNERIA SPIRALIS	7.0-9.0(7),4.9(13),5.5-7.0(21),5.6-10.0(25),6.5-9.7(50),7.1-8.7(54),6.7-9.3(59),5.6-7.9(61),7.0-8.9(70),7.5-9.8(71),5.8-10.2(72)
WOLFFIA	4.0-10.0(1),8.5(25),5.8-8.5(27),6.5-7.2(59),6.1-6.7(61),7.2-8.4(67),6.8-7.9(72)
WOLFFIA ARRHIZA	4.0-10.0(1),6.5-7.2(59)
WOLFFIA BOREALIS	8.5(25),6.0-8.5(27),6.8-7.9(72)
WOLFFIA COLUMBIANA	5.8-8.5(27),6.5-6.7(61),7.2-8.4(67),6.8-7.9(72)
WOLFFIA BRASILIENSIS	6.1-6.7(61)
WOLFFIELLA	4.8-6.8(27)
WOLFFIELLA FLORIDANA	4.8-6.8(27),6.1-6.6(61),
XYRIS	4.7-8.2(61)
XYRIS IRIDIFOLIA	5.0-8.2(61)
XYRIS PLATYLEPIS	4.7-6.6(61)
XYRIS SMALLIANA	5.0(61)
ZANNICHELLIA PALUSTRIS	5.6-10.5(25),7.4(35),7.7-8.5(54),8.2-8.9(57,58),8.7-9.8(60),7.5(61),7.6-9.0(67),8.4-10.5(74)
ZIZANIA AQUATICA	6.4-7.4(61),7.2-8.8(67),7.7-9.8(71)
ZIZANIOPSIS MILIACEA	6.1-6.8(61)

DICOTYLEDONS

AESCHYNOMENE	6.3-8.5(61)
AESCHYNOMENE INDICA	8.5(61)
AESCHYNOMENE VIRGINICA	6.3-7.8(61)
AGERATUM	6.8-7.6(29)
AGERATUM CONYZOIDES	6.8-7.6(29)
ALTERNANTHERA	3.5-5.9(20),6.8-7.6(29),5.9-6.8(61)
ALTERNANTHERA PHILOXEROIDES	3.5-5.9(20),5.9-6.8(61)
ALTERNANTHERA SESSILIS	6.8-7.6(29)
APIUM NODIFLORUM	7.0-8.4(56)

BACOPA 5.4-7.7(61)
BACOPA CAROLINIANA 5.9(61)
BACOPA CYCLOPHYLLA 6.6(61)
BACOPA MONNIERI 5.4-7.7(61)
BATRACHIUM NIPPONICUS 7.1-8.3(59)
BERULA ERECTA 7.0-8.4(56),7.7-8.2(57,58)
BRASENIA SCHREBERI 3.5-5.9(20),4.0-7.6(21),5.6-10.0(25),6.4-7.4(44),
5.6-8.7(50),6.3-8.5(54),5.7-9.4(59),4.8-7.2(61),
7.6-8.8(67),5.6-9.8(71),5.7-9.5(72)
CABOMBA CAROLINIANA 6.8-7.8(59),5.7-9.2(61),5.9-7.8(72)
CALLITRICHE 7.4(6),5.6-9.2(25),6.7(30),5.9-7.1(34),4.6-5.1(35),
5.8-6.8(40),6.2-7.3(41),5.8-6.5(43),6.0-6.9(46),
4.2-5.8(47),7.7-8.5(54),7.0-8.4(56),7.0-8.2(57,58),
5.1-9.6(60),5.2-7.2(61),5.7-8.2(70),7.7-7.8(73),
6.9(74)
CALLITRICHE ANCEPS 5.6-9.2(25)
CALLITRICHE COPHOCARPA 6.2-7.3(41),5.8-7.3(60)
CALLITRICHE HAMULATA 7.0(60)
CALLITRICHE HERMAPHRODITICA 5.6-9.2(25),7.7-8.5(54),6.0-8.4(60),
6.8-8.2(70)
CALLITRICHE HETEROPHYLLA 5.6-9.2(25),5.2-7.2(61)
CALLITRICHE INTERMEDIA 5.8-6.5(43)
CALLITRICHE OBTUSANGULA 7.0-8.4(56)
CALLITRICHE POLYMORPHA 5.9-7.1(34),5.8-6.8(40),6.2-7.3(41),
7.0-8.2(57,58)
CALLITRICHE STAGNALIS 7.4(6),6.0-9.1(25),7.0-8.4(56),7.0-8.2(57,58),
7.7(73)
CALLITRICHE VERNA 6.0-8.8(25),6.7(30),4.6-5.1(35),6.2-7.3(41),
6.0-6.9(46),4.2-5.8(47),5.1-9.6(60),5.7-8.2(70)
CARDAMINE PRATENSE 7.3(73)
CERATOPHYLLUM 7.4(6),3.5-5.9(21),5.6-10.0(25),7.0-9.3(32),
6.2-7.3(41),6.5(45),6.0-6.9(46),6.1-9.7(50),
7.1-8.7(54),6.4-9.3(57,58),6.0-9.4(59),6.2-8.2(60),
5.6-8.3(61),7.6-8.0(62),6.3-9.0(67),5.7-8.9(70),
7.5-9.8(71),5.7-8.9(72),8.5(73),7.8-9.7(74)
CERATOPHYLLUM DEMERSUM 7.4(6),5.6-10.0(25),7.0-9.3(32),6.2-7.3(41),
6.5(45),6.0-6.9(46),6.1-9.7(50),7.1-8.7(54),
6.4-9.3(57,58),6.0-9.4(59),6.2-8.2(60),
6.2-8.3(61),7.6-8.0(62),6.3-9.0(67),
5.7-8.9(70),7.5-9.8(71),5.9-8.9(72),8.5(73),
7.8-9.7(74)
CERATOPHYLLUM ECHINATUM 3.5-5.9(20),6.5-8.0(25),5.6-6.1(61),
5.7-7.8(72)
CICUTA 6.0-6.4(22),5.6-10.0(25),7.4(37),6.2-7.3(41),5.9-9.6(60),
5.7-9.0(70),8.7(73)
CICUTA BULBIFERA 6.0-6.4(22),6.4-8.6(25)
CICUTA DOUGLASII 5.6-10.0(25)
CICUTA VIROSA 7.4(37),6.2-7.3(41),5.9-9.6(60),5.7-9.0(70),8.7(73)
CUPHEA CARTHAGENSIS 5.2-7.7(61)
DECODON VERTICILLATUS 4.7-7.1(61),7.5-9.8(71)
ELATINE 4.7-7.0(21),6.2-7.3(41),7.0(44),6.0-6.9(46),5.3-5.8(47),
5.9-8.7(60),7.2(61),5.7-8.0(70),5.6-9.8(71)
ELATINE HYDROPIPER 6.2-7.3(41),6.0-6.9(46),5.3-5.8(47),5.9-8.6(60),
5.7-8.0(70)
ELATINE ORTHOSPERMA 6.6-7.3(60)
ELATINE TRIANDRA 4.7-7.0(21),6.2-7.3(41),7.0(44),6.0-6.9(46),
5.3-5.8(47),6.1-7.6(60),7.2(61),5.7-8.0(70)
EPILOBIUM 7.4(37),7.0-8.4(56)
EPILOBIUM HIRSUTUM 7.0-8.4(56)
EPILOBIUM PALUSTRE 7.4(37)
EUPATORIUM CANNABINUM 7.0-8.4(56)
EURYALE FEROX 6.5-10.1(59)

GALIUM PALUSTRE	7.4(37)
GRATIOLA	5.6-9.2(25),5.1-7.7(61),7.5(71)
GRATIOLA AUREA	7.5(71)
GRATIOLA EBRACTEATA	6.5-7.8(25)
GRATIOLA NEGLECTA	5.6-9.2(25),5.1-7.7(61)
GRATIOLA VIRGINIANA	6.6(61)
GRATIOLA VISCIDULA	6.0-7.3(61)
HIPPURIS VULGARIS	7.4(6),5.0-10.0(25),6.7(30),5.9-7.1(34),4.6-5.1(35),7.4(37),6.2-7.3(41),6.4(44),6.0-6.9(46),4.2-5.3(47),7.8(57,58),5.7-9.8(60),6.8-8.8(67),5.7-8.9(70),6.5-7.3(72),9.3(74)
HOTTONIA	7.4(6),6.6-7.1(61),6.3-8.9(70)
HOTTONIA INFLATA	6.6-7.1(61)
HOTTONIA PALUSTRIS	7.4(6),6.3-8.9(70)
HYDROCOTYLE	3.5-5.9(20),4.8-9.3(61),7.3(73)
HYDROCOTYLE AMERICANA	6.8(61)
HYDROCOTYLE BONARIENSIS	3.5-5.9(20),7.6(61)
HYDROCOTYLE RANUNCULOIDES	6.3(61)
HYDROCOTYLE UMBELLATA	4.9-9.3(61)
HYDROCOTYLE VULGARIS	7.3(73)
HYDROLEA QUADRIVALVIS	5.8-8.3(61)
JUSTICIA	5.1-7.5(61)
JUSTICIA AMERICANA	6.2-7.5(61)
JUSTICIA OVATA	5.1-7.4(61)
LILAEOPSIS OCCIDENTALIS	6.5-7.8(25)
LIMNOPHILA SESSILIFLORA	6.2-7.8(59)
LIMOSELLA	5.6-9.2(25),5.9-6.8(34),6.2-7.3(41),6.6(60),6.4-7.0(70),
LIMOSELLA AQUATICA	5.6-9.2(25),5.9-6.8(34),6.2-7.3(41),6.6(60),6.4-7.0(70),
LIMOSELLA SUBULATA	6.9(25)
LINDERNIA DUBIA	5.1-9.1(61)
LITTORELLA	4.2-6.7(3),3.5-6.5(8),5.2-6.4(43),6.0-6.9(46),5.8-6.0(47) 6.5-8.2(53),5.2-9.0(57,58),6.4-8.7(71),7.0-9.3(73)
LITTORELLA AMERICANA	6.4-8.7(71)
LITTORELLA UNIFLORA	4.2-6.7(3),3.5-6.5(8),5.2-6.4(43),6.0-6.9(46),5.8-6.0(47),6.5-8.2(53),5.2-9.0(57,58),6.0-8.8(70),7.0-9.3(73)
LOBELIA	4.2-6.7(3),4.0-6.0(4),4.9(13),4.4-7.0(21),3.7-8.9(25),6.7(30),6.9-7.1(36),6.9-7.1(39),5.6-7.4(44),6.0-6.9(46),5.8-6.0(47),6.5-8.2(53),6.3-6.5(54),4.1-8.3(57,58),6.1-7.5(60),5.8-7.8(61),4.8(66),6.8-8.5(67),6.0-7.9(70),5.8-9.8(71),7.7)73)
LOBELIA AMOENA	6.8(61)
LOBELIA CARDINALIS	5.8-7.8(61)
LOBELIA DORTMANNA	4.2-6.7(3),4.0-6.0(4),4.9(13),4.4-7.0(21),3.7-8.9(25),6.7(30),6.9-7.1(36),6.9-7.1(39),5.6-7.4(44),6.0-6.9(46).5.8-6.0(47),6.5-8.2(53),6.3-6.5(54),4.1-8.3(57,58),6.1-7.5(60),4.8(66),6.8-8.5(67),6.0-7.9(70),5.8-9.8(71),7.7(73)
LOBELIA ELONGATA	6.2(61)
LOBELIA NUTTALLII	7.0(61)
LUDWIGIA	6.0-9.3(25),6.8-7.6(29),4.7-10.0(61),7.5-9.4(65),3.1-6.4(69)
LUDWIGIA ALTERNIFOLIA	4.7-10.0(61)
LUDWIGIA BREVIPES	5.2-6.2(61)
LUDWIGIA DECURRENS	5.7-7.8(61)
LUDWIGIA DIFFUSA	7.5(65)
LUDWIGIA GLANDULOSA	6.0-7.3(61)
LUDWIGIA LEPTOCARPA	6.8-7.6(29),5.3-7.6(61)
LUDWIGIA LINEARIS	4.7-6.7(61)
LUDWIGIA PALUSTRIS	6.0-9.3(25),5.0-8.6(61),3.1-6.4(69)
LUDWIGIA PILOSA	4.8-7.7(61)
LUDWIGIA SPHAEROCARPA	4.9-5.5(61)
LUDWIGIA URUGUAYENSIS	6.1-7.3(61)

LYCOPUS EUROPAEUS	5.9-6.8(34),7.4(37)
LYSIMACHIA	5.5-6.5(22),6.6-8.5(25),6.7(30),7.0-9.3(32),5.9-7.1(34),7.4(37),6.2-7.3(41),6.8-7.4(44),6.0-6.9(46),4.2-5.3(47),5.1-9.8(60),5.9-6.6(61),5.7-9.0(70)
LYSIMACHIA TERRESTRIS	6.8-7.4(44),5.9-6.6(61)
LYSIMACHIA THYRSIFLORA	5.5-6.5(22),6.6-8.5(25),6.7(30).7.0-9.3(32),5.9-7.1(34),7.4(37),6.2-7.3(41),6.0-6.9(46),4.2-5.3(47),5.1-9.8(60),5.7-9.0(70)
LYSIMACHIA VULGARIS	5.9-7.1(34)
LYTHRUM	5.9-7.1(34),7.4(37),7.0-8.4(56),6.4-7.8(60),6.6-8.6(61)
LYTHRUM LINEARE	8.3-8.6(61)
LYTHRUM SALICARIA	5.9-7.1(34),7.4(37),7.0-8.4(56),6.4-7.8(60)
MECARDONIA ACUMINATA	7.0(61)
MEGALODONTA BECKII	5.6-9.2(25),7.1-8.5(54),7.0-8.8(67),7.3-9.8(71)
MENTHA AQUATICA	7.0-8.4(56),6.2-8.4(57,58)
MICRANTHEMUM UMBROSUM	5.3-8.3(61)
MIMULUS	5.6-10.0(25),5.3-8.2(61)
MIMULUS ALATUS	6.1-7.9(61)
MIMULUS FLORIBUNDUS	5.6-9.2(25)
MIMULUS GLABRATUS	6.7-8.9(25)
MIMULUS GUTTATUS	5.6-10.0(25)
MIMULUS RINGENS	5.3-8.2(61)
MONTIA FONTANA	7.1-8.0(25),7.0-8.4(60),7.3(73)
MYOSOTIS	5.6-10.2(25),7.0-8.4(56),7.3(60),7.2(73)
MYOSOTIS LAXA	5.6-10.0(25)
MYOSOTIS SCORPIOIDES	6.5-10.2(25),7.0-8.4(56),7.3(60),7.2(73)
MYRIOPHYLLUM	7.4(6),7.0-9.0(7),4.9(13),4.0-10.0(14),2.9-10.0(15),4.4-7.6(21),5.6-10.5(25),6.7(30),5.9-7.1(34),7.4(35),6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41),6.0-7.4(44),6.5(45),6.0-6.9(46),4.2-6.0(47),6.0-8.1(49),5.9-9.6(50),6.3-8.7(54),6.2-8.9(57,58),6.3-9.9(59),5.7-9.8(60),4.3-9.0(61),7.6-8.0(62),4.8(66),7.2-8.9(67),6.2-10.2(68),3.5-6.8(69),5.7-8.9(70),5.6-9.8(71),5.8-10.2(72),7.0-8.7(73),7.8-10.5(74)
MYRIOPHYLLUM ALTERNIFLORUM	6.7(30),5.9-7.1(34),6.9-7.1(36),7.4(37),6.9-7.1(39),6.5(45),6.0-6.9(46),4.5-6.0(47),6.0-8.1(49),6.2-8.2(57,58),5.7-7.6(60),5.7-8.8(70),7.5-7.7(71),6.5-8.0(72),7.0-7.8(73)
MYRIOPHYLLUM AQUATICUM	5.2-7.7(61)
MYRIOPHYLLUM EXALBESCENS	5.6-10.5(25),7.2-8.9(67),6.2-10.2(68),6.8-9.8(72),7.8-10.5(74)
MYRIOPHYLLUM FARWELLII	6.3-7.6(25),6.8-7.4(44),6.3-8.5(54),6.1-7.1(72)
MYRIOPHYLLUM HETEROPHYLLUM	7.1(54),5.0-9.0(61),3.5-6.8(69),6.2-8.9(72)
MYRIOPHYLLUM HIPPUROIDES	6.4-7.8(25)
MYRIOPHYLLUM HUMILE	5.8-7.0(72)
MYRIOPHYLLUM LAXUM	4.9(6.1)
MYRIOPHYLLUM PINNATUM	6.6-7.3(61)
MYRIOPHYLLUM SPICATUM	7.0-9.0(7),4.0-10.0(14),2.9-10.0(15),6.5-9.7(25),7.4(35),6.8-8.1(49),6.5-9.6(50),6.0-8.9(57,58),6.1-9.8(60),6.4-8.7(70),7.3-9.8(71),6.7-10.2(72),8.5-8.7(73)
MYRIOPHYLLUM TENELLUM	4.9(13),4.4-7.6(21),6.0-7.4(44),4.8(66),5.6-8.1(71),5.9-10.2(72)
MYRIOPHYLLUM USSURIENSE	5.6-9.2(25),6.3-8.5(50),6.3-9.9(59)

MYRIOPHYLLUM VERTICILLATUM	6.2-10.0(25),7.4(37),6.2-7.3(41),6.5(45),6.0-6.9(46),4.2-5.3(47),6.8-7.8(49),5.9-8.7(50),7.7-8.5(54),7.8-8.0(57,58),6.6-7.6(59),5.8-7.8(60),7.6-8.0(62),6.3-8.9(70),6.5-8.7(71),6.5-7.8(72)
NELUMBO	3.5-5.9(20),6.2-9.8(59),4.5-7.3(61),7.0(65)
NELUMBO NUCIFERA	6.2-9.8(59)
NELUMBO PENTAPETALA	3.5-5.9(20),4.5-7.3(61),7.0(65)
NUPHAR	7.4(6),4.9(13),4.0-7.6(21),3.7-10.0(25),6.7(30),7.0-9.3(32),5.9-7.1(34),7.4(37),5.8-6.8(40),6.2-7.3(41),4.4-7.4(44),6.0-6.9(46),4.2-5.3(47),5.9-9.2(50),6.3-8.7(54),5.4-9.0(57,58),6.1-8.2(59),4.4-9.8(60),4.2-7.7(61),4.8(66),6.8-8.6(67),4.9-[illegible].9(70),5.8-9.8(71),5.0-9.8(72)
NUPHAR JAPONICUM	5.9-9.2(50)
NUPHAR LUTEA	7.4(6),4.9(13),6.7(30),7.0-9.3(32),5.9-7.1(34),7.4(37),5.8-6.8(40),6.2-7.3(41),6.0-6.9(46),4.2-5.3(47),5.4-9.0(57,58),4.4-9.8(60),4.2-7.7(61),4.9-8.9(70)
NUPHAR MICROPHYLLUM	6.8-7.3(67),6.5-9.6(71)
NUPHAR POLYSEPALUM	3.7-10.0(25)
NUPHAR PUMILA	6.7(30),7.4(37),5.3-7.2(50),4.4-9.6(60),5.7-7.6(70),6.5-9.5(72)
NUPHAR RUBRODISCUM	6.8-7.3(67),6.0-9.8(71)
NUPHAR SUBINTEGERRIMUM	6.1-8.2(59)
NUPHAR VARIEGATUM	4.0-7.6(21),6.5-8.9(25),6.3-8.7(54),6.8-8.6(67),5.8-9.8(71),5.0-9.8(72)
NYMPHAEA	7.4(6),3.5-5.9(20),4.0-7.6(21),5.6-8.5(25),6.8-7.6(29),6.7(30),7.0-9.3(32),5.9-6.8(34),7.4(37),6.9-7.1(39),5.8-6.8(40),6.2-7.3(41),4.3-7.4(44),6.5(45),6.0-6.9(46),4.2-5.3(47),4.9-8.6(50),6.9-8.7(54),3.4-8.9(57,58),5.8-9.4(59),5.6-9.6(60),7.6-8.0(62),5.7-8.9(70),5.6-9.8(71),5.3-9.5(72)
NYMPHAEA ALBA	7.4(6),6.7(30),7.0-9.3(32),5.9-6.8(34),5.8-6.8(40),3.4-8.9(57,58),7.6-8.0(62),5.7-8.9(70)
NYMPHAEA CANDIDA	6.7(30),7.4(37),6.9-7.1(39),6.2-7.3(41),6.5(45),6.0-6.9(46),4.2-5.3(47),5.6-9.6(60)
NYMPHAEA LOTUS	6.8-7.6(29)
NYMPHAEA ODORATA	3.5-5.9(20),4.0-7.6(21),7.4(37),4.3-7.4(44),6.9-8.7(54),4.5-9.4(61),7.6-8.4(67),5.3-9.5(72)
NYMPHAEA TETRAGONA	6.7(30),6.0-6.9(46),4.9-8.6(50),5.8-9.4(59),6.2-7.4(60),7.0-7.3(72)
NYMPHAEA TUBEROSA	6.3-9.0(67),5.6-9.8(71),6.8-8.6(72)
NYMPHOIDES	3.5-5.9(20),4.4-6.1(21),5.9-8.8(59),4.9-6.4(61),4.8(66),
NYMPHOIDES AQUATICA	3.5-5.9(20),4.9-6.4(61)
NYMPHOIDES CORDATUM	4.4-6.1(21),4.9-6.0(61),4.8(66)
NYMPHOIDES INDICA	5.9-10.9(50),6.6-8.7(59)
NYMPHOIDES PELTATA	5.9-8.8(59)
OENANTHE	5.9-10.0(25),7.0-8.4(57,58),6.2-8.9(70)
OENANTHE AQUATICA	7.0-8.4(57,58),6.2-8.9(70)
OENANTHE SARMENTOSA	5.9-10.0(25)
PENTODON PENTANDRUS	6.8-7.6(29)
PEPLIS	6.7-7.3(41),5.8-7.6(61)
PEPLIS DIANDRA	5.8-6.6(61)
PEPLIS PORTULA	6.2-7.3(41)
PODOSTEMUM CERATOPHYLLUM	6.8-7.8(61)
POLYGONUM	3.5-5.9(20),5.6-10.2(25),6.8-7.6(29),7.0-9.3(32),5.9-7.1(34),7.4(37),6.2-7.3(41),6.4-7.9(44),6.0-6.9(46),4.2-5.3(47),6.5-8.2(53),8.2-8.7(54),3.4-9.0(57,58),6.1-7.6(60),4.5-8.7(61),7.3-8.8(67),5.7-9.3(68),6.2-8.8(70),7.1-9.8(71),7.8-10.5(74)
POLYGONUM AMPHIBIUM	5.6-10.2(25),7.0-9.3(32),6.2-7.3(41),6.4-7.9(44) 6.0-6.9(46),4.2-5.3(47),6.5-8.2(53),8.2-8.7(54),3.4-9.0(57,58),6.1-7.6(60),7.3-8.8(67),5.7-9.3(68),6.2-8.8(70),7.1-9.8(71),7.8-10.5(74)

POLYGONUM ARIFOLIUM	6.0-7.3(61)
POLYGONUM DENSIFLORUM	6.4(61)
POLYGONUM HIRSUTUM	7.4(61)
POLYGONUM HYDROPIPER	6.9-8.7(25),5.9-7.1(34)
POLYGONUM HYDROPIPEROIDES	3.5-5.9(20),7.0-10.0(25),4.5-7.9(61),
POLYGONUM LAPPATHIFOLIUM	8.7(25)
POLYGONUM PUNCTATUM	3.5-5.9(20),6.0-8.7(61)
POLYGONUM SAGITTATUM	5.8-8.4(61)
POLYGONUM SALICIFOLIUM	6.8-7.6(29)
POTENTILLA PALUSTRIS	4.3-6.3(22),7.4(37),5.8-6.8(40),6.2-7.3(41), 5.4-10.4(60),6.1-9.8(71),7.3-8.7(73)
PROSERPINACA	4.3-6.8(61),5.4-7.3(72)
PROSERPINACA INTERMEDIA	4.9-5.9(61)
PROSERPINACA PALUSTRIS	4.3-6.8(61),5.4-7.3(72)
PROSERPINACA PECTINATA	5.0-6.1(61)
RANUNCULUS	6.5-10.3(18),4.6-6.4(21),6.4(22),3.7-10.2(25),6.7(30), 7.0-9.3(32),5.9-7.1(34),6.9-7.1(36),7.4(37),6.9-7.1(39), 6.2-7.3(41),6.5(45),6.0-6.9(46),4.2-6.0(47),7.1-8.5(54), 5.8-8.9(57,58),5.6-10.4(60),6.0-7.3(61),7.1-8.8(67), 5.7-8.9(70),6.1(71),6.0-7.8(73)
RANUNCULUS AQUATILIS	5.6-10.0(25),7.1-8.5(54),7.2-8.4(57,58), 7.1-8.8(67),6.3-8.9(70),7.5-9.8(71), 7.0-7.8(73)
RANUNCULUS CYMBALARIA	7.6-10.3(25)
RANUNCULUS FLABELLARIS	6.4(22),5.6-9.2(25)
RANUNCULUS FLAMMULA	4.6-6.4(21),3.7-10.0(25),6.7(30),5.9-7.1(34), 6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41), 6.0-6.9(46),4.2-5.8(47),5.8-8.3(57,58), 5.6-9.4(60),5.7-8.8(70),6.1(71),6.0-7.3(73)
RANUNCULUS HYPERBOREUS	5.6-9.2(25)
RANUNCULUS LINGUA	6.2-7.3(41),6.5(45),6.2-8.9(70)
RANUNCULUS PELTATUS	6.9-7.1(36),7.4(37),6.9-7.1(39),6.2-7.3(41), 6.5(45),6.0-6.9(46),5.3-6.0(47),7.0-8.4(56), 7.7-8.2(57,58),5.7-10.4(60),5.7-7.9(70)
RANUNCULUS PENICILLATUS	6.5-10.3(18),7.0-8.4(56)
RANUNCULUS PSEUDOFLUITANS	7.2-8.9(57,58)
RANUNCULUS PUSILLUS	6.6-7.1(61)
RANUNCULUS REPENS	7.0-9.3(32)
RANUNCULUS SCELERATUS	6.7-10.2(25),7.4(37),7.3(61)
RANUNCULUS SUBCORDATUS	6.0-6.8(61)
ROTALA RAMOSIOR	6.2-7.6(61)
RORIPPA	5.6-9.8(25),7.4(37),6.2-7.3(41),7.0-8.4(56),8.2(57,58), 6.7-7.1(61)
RORIPPA AMPHIBIA	6.2-7.3(41)
RORIPPA NASTURTIUM-AQUATICUM	5.6-9.8(25),7.0-8.4(56),8.2(57,58), 6.7-7.1(61)
RORIPPA PALUSTRIS	7.4(37)
RUMEX	6.2-7.3(41),8.0-8.9(57,58),5.9-9.8(60),6.1-7.2(61), 6.3-8.9(70)
RUMEX AQUATICUM	5.9-9.8(60)
RUMEX HYDROLAPATHUM	6.2-7.3(41),8.0-8.9(57,58),6.3-8.9(70)
RUMEX VERTICILLATUS	6.1-7.2(61)
SAMOLUS PARVIFLORUS	6.1-8.7(61)
SCROPHULARIA AURICULATA	7.0-8.4(56)
SIUM	5.6-10.0(25),7.0-8.4(57,58),6.6-9.0(68),6.3-8.9(70),
SIUM LATIFOLIUM	7.0-8.4(57,58),6.3-8.9(70)
SIUM SAUVE	5.6-10.2(25),6.6-9.0(68)
SOLANUM DULCAMARA	7.0-8.9(57,58)
SUBULARIA AQUATICA	5.6-9.2(25),6.7(30),6.9-7.1(36),6.9-7.1(39), 6.0-6.9(46),5.3-6.0(47),5.6-9.0(60),5.7-8.3(70)
TILLAEA AQUATICA	5.6-9.2(25),5.7-7.0(70),5.9-6.8(34)

TRAPA	5.9-10.2(50),6.0-10.5(59),6.7-8.2(72)
TRAPA INCISA	7.0-8.1(59)
TRAPA JAPONICA	5.9-10.2(50),6.0-10.5(59)
TRAPA NATANS	6.7-10.0(50),6.7-8.2(72)
UTRICULARIA	4.9(13),3.5-5.9(20),4.0-7.6(21),4.6-6.9(22),3.7-10.2(25),6.7(30),7.0-9.3(32),5.9-6.8(34),7.4(37),6.2-7.3(41),4.4-7.4(44),6.5(45),6.0-6.9(46),4.2-5.3(47),4.9-8.3(50),6.3-8.5(54),8.3(57,58),5.7-9.3(59),4.4-9.4(60),4.6-7.6(61),4.8(66),6.8-8.8(67),6.5-9.5(68),5.7-8.9(70),6.5-9.8(71),3.5-8.6(72),7.0-8.0(73),6.9(74)
UTRICULARIA AUREA	5.7-9.3(59)
UTRICULARIA AUSTRALIS	5.9-8.7(59)
UTRICULARIA CORNUTA	4.6-6.9(22),5.2-7.6(61),5.6-6.9(72)
UTRICULARIA EXOLETA	7.2-7.4(59)
UTRICULARIA GEMINISCAPA	4.8(66),3.5-8.6(72)
UTRICULARIA GIBBA	3.5-5.9(20),6.1-7.8(25),7.0(44),4.6-7.0(61),6.5(71),5.8-8.6(72)
UTRICULARIA INFLATA	6.1-7.6(61)
UTRICULARIA INTERMEDIA	4.6-6.9(22),3.7-8.9(25),6.7(30),6.2-7.3(41),5.6-6.8(44),6.0-6.9(46),4.3-5.3(47),6.3-8.5(54),4.4-7.3(60),7.7-8.6(67),6.5-8.8(68),5.9-7.9(72),7.2(73)
UTRICULARIA JAPONICA	4.9-8.3(50)
UTRICULARIA MINOR	5.9-6.9(22),5.8-9.0(25),5.9-6.8(34),7.4(37),6.2-7.3(41),4.4(44),4.2-4.9(47),6.9-8.5(54),8.3(57,58),6.8(59),5.7-8.2(60),6.9-8.3(68),6.5(71),6.0-8.1(72)
UTRICULARIA OLIVACEA	4.9(61)
UTRICULARIA PURPUREA	4.3-7.6(21),5.6-6.0(44),6.3(54),5.0-7.5(61),4.8(66),6.5(71),5.6-7.3(72)
UTRICULARIA RADIATA	5.6-7.3(72)
UTRICULARIA RESUPINATA	4.4-7.6(21),6.8(61),4.8(66)
UTRICULARIA SUBULATA	4.6(61)
UTRICULARIA VULGARIS	4.0-7.6(21),3.7-10.2(25),7.0-9.3(32),5.9-6.8(34),7.4(37),6.2-7.3(41),4.6-7.4(44),6.5(45),6.0-6.9(46),4.2-5.3(47),6.3-8.5(54),5.1-9.4(60),6.8-8.8(67),6.5-9.5(68),5.7-8.9(70),6.5-9.8(71),5.7-8.6(72),7.0-8.0(73),6.9(74)
VERONICA	5.6-10.0(25),7.0-9.3(32),5.9-6.8(34),7.0-8.4(56),7.8(57,58),7.2(73)
VERONICA AMERICANA	5.6-10.0(25)
VERONICA ANAGALLIS-AQUATICA	6.0-7.9(25),7.8(57,58)
VERONICA BECCABUNGA	7.0-8.4(56)
VERONICA CATENATA	7.0-8.4(56)
VERONICA SCUTELLATA	5.6-9.2(25),7.0-9.3(32),5.9-6.8(34),7.2(73)

PH RANGES FOR AQUATIC PLANT GENERA AND SPECIES

1.AQUATIC MACROALGAE

CHARA	5.3-10.2
CHARA ACULEOLATA	7.7-8.4
CHARA ASPERA	7.0-9.3
CHARA BRAUNII	6.6-8.6
CHARA CANESCENS	8.0-8.9
CHARA CONTRARIA	7.7-8.4
CHARA CORALLINA	5.3-9.1
CHARA DELICATULA	8.7-9.3
CHARA FRAGILIS	5.6-9.2
CHARA GLOBULARIS	6.1-9.8
CHARA HISPIDA	8.2-8.5
CHARA INTERMEDIA	7.1
CHARA PAPILLOSUM	8.7
CHARA RUDIS	7.6-8.5
CHARA STRIGOSA	7.3-8.5
CHARA TOMENTOSA	7.4-8.2
CHARA VULGARIS	7.4-8.7
HYDRODICTYON AFRICANUM	5.7-9.8
LAMPROTHAMNIUM PAPULOSUM	8.0-8.8
NITELLA	4.8-9.3
NITELLA CONFERVACEAE	6.6-8.0
NITELLA FLEXILIS	5.5-7.8
NITELLA GRACILIS	6.9-8.5
NITELLA MUCRONATA	7.2-8.6
NITELLA OPACA	6.3-9.3
NITELLA TENUIFOLIA	7.6-8.2
NITELLA TENUISSIMA	4.8-8.5
NITELLA TRANSLUCENS	7.0-8.0
NITELLA WAHLBERGIANA	6.2-7.3
TOLYPELLA	7.7-8.7
TOLYPELLA INTRICATA	7.7-8.7
TOLYPELLA NIDIFOLIA	8.0-8.6

2. AQUATIC LIVERWORTS

CHILOSCYPHUS PALLESCENS	6.5-7.6
MARCHANTIA POLYMORPHA	6.3-6.9
MARSUPELLA EMARGINATA	5.2-6.3
NARDIA COMPRESSA	5.3-5.9
RICCIA FLUITANS	6.5-8.8
RICCIOCARPUS NATANS	5.6-9.2
SCAPANIA	5.3-7.1
SCAPANIA DENTATA	5.3-6.6
SCAPANIA IRRIGUA	5.8
SCAPANIA ULIGINOSA	5.3-5.7
SCAPANIA UNDULATA	5.3-7.1

3. AQUATIC MOSSES

CALLIERGON	5.6-7.8
CALLIERGON CORDIFOLIUM	6.7-6.9
CALLIERGON GIGANTEUM	6.3-7.6
CALLIERGON MEGALOPHYLLUM	5.6-7.8
CALLIERGON RICHARDSONII	6.1-7.8
CALLIERGON SARMENTOSUM	6.3
CALLIERGON STRAMINEUM	5.7-7.1
CALLIERGOON TRIFARIUM	6.3-7.2
CALLIERGONELLA CUSPIDATA	6.2-7.6
CAMPYLIUM	6.0-7.6
CAMPYLIUM POLYGAMUM	6.3-7.6
CAMPYLIUM STELLATUM	6.3-7.6
CLADOPODIELLA FLUITANS	4.2-5.8
CRATONEURON COMMITATUM	7.3
DREPANOCLADUS	4.6-9.3
DREPANOCLADUS ADUNCUS	6.2-7.6
DREPANOCLADUS CAPILLIFOLIUS	5.8-9.0
DREPANOCLADUS EXANNULATUS	4.9-7.8
DREPANOCLADUS FLUITANS	4.6-7.0
DREPANOCLADUS PROCERUS	4.8-9.0
DREPANOCLADUS REVOLVENS	6.6-8.0
DREPANOCLADUS SENDTERI	6.2-7.3
DREPANOCLADUS TENUINERVIS	6.0-8.0
DREPANOCLADUS TRICHOPHYLLUS	5.0-9.0
DREPANOCLADUS TUNDRAE	6.4-7.4
DREPANOCLADUS UNCINATUS	7.0-9.3
FISSIDENS	6.3-7.8
FISSIDENS ADIANTHOIDES	6.8-7.0
FISSIDENS FONTANUM	7.3-7.8
FISSIDENS OSMONDOIDES	6.3-7.2
FONTINALIS	4.0-9.5
FONTINALIS ANTIPYRETICA	5.4-9.5
FONTINALIS DALECARLICA	5.7-7.5
FONTINALIS HYPNOIDES	5.6-8.4
FONTINALIS NOVAE-ANGLIAE	6.0-7.2
FONTINALIS SQUAMOSA	5.6-7.1
HYGROAMBLYSTEGIUM FLUVIATILE	6.2-7.3
HYGROHYPNUM	5.7-7.3
HYGROHYPNUM LURIDUM	6.9
HYGROHYPNUM OCHRACEUM	5.7-7.3
LEPIDODICTYUM	3.3-7.5
LEPIDODICTYUM KOCHII	6.2-7.3
LEPIDODICTYUM RIPARIUM	3.3-7.5
POLYTRICHUM COMMUNE	4.2-6.8
PLATYHYPNIDIUM RIPAROIDES	6.6-9.3
SCORPIDIUM SCORPIOIDES	5.6-8.4
SPHAGNUM	3.4-7.4
SPHAGNUM ANNULATUM	4.4-7.0
SPHAGNUM AONGSTROEMII	5.5
SPHAGNUM BALTICUM	6.3
SPHAGNUM COMPACTUM	4.8-7.1
SPHAGNUM CONTORTUM	6.8
SPHAGNUM CUSPIDATUM	3.6-7.3
SPHAGNUM LINDBERGIA	5.0-5.4
SPHAGNUM MAUUS	4.4-7.0
SPHAGNUM PALUSTRE	6.6-7.3
SPHAGNUM PAPILLOSUM	4.4-6.2
SPHAGNUM PARVIFOLIUM	5.8-6.8
SPHAGNUM PLATYPHYLLUM	4.9-7.4
SPHAGNUM PLUMULOSUM	6.0-6.6

SPHAGNUM PULCHRUM   6.4
SPHAGNUM PYLAESII   4.9
SPHAGNUM RIPARIUM   4.8-7.4
SPHAGNUM SQUARROSUM   6.6-8.7
SPHAGNUM SUBSECUNDUM   3.4-7.3

4. AQUATIC QUILLWORTS

ISOETES   3.7-9.8
ISOETES BRAUNII   7.0-8.0
ISOETES ECHINOSPORA   5.0-9.8
ISOETES JAPONICA   6.8-8.9
ISOETES LACUSTRIS   4.4-8.6
ISOETES MURICATA   4.1-7.9
ISOETES RIPARIA   6.0-7.4
ISOETES SETACEA   6.2-7.3

5. AQUATIC HORSETAILS

EQUISETUM   4.2-10.4
EQUISETUM FLUVIATILE   4.2-10.4
EQUISETUM PALUSTRE   5.6-9.2

6. AQUATIC FERNS

AZOLLA FILICULOIDES   6.5-8.2
MARSILEA   5.7-8.7
MARSILEA QUADRIFOLIA   6.8-7.6
MARSILEA VESTITA   5.7-8.7
SALVINIA   5.2-9.5
SALVINIA AURICULATA 5.2-9.5
SALVINIA NATANS   6.0-7.7
SALVINIA NYMPHELLULA   6.8-7.6

7. AQUATIC FLOWERING PLANTS

MONOCOTYLEDONS

ACORUS CALAMUS   6.2-9.0
AGROSTIS   6.0-8.7
AGROSTIS CANINA   7.4-8.7
AGROSTIS STOLONIFERA   7.2-8.0
AGROSTIS TENUIS   6.0-7.3
ALISMA   4.2-10.2
ALISMA CANALICULATUM   6.6-7.8
ALISMA GRAMINEUM   6.5-8.9
ALISMA PLANTAGO-AQUATICA   4.2-10.2
ALOPECURIS   5.6-9.3
ALOPECURIS AEQUALIS   5.6-9.3
ALOPECURIS CAROLINIANUS   6.4-7.1
ANEILEMA KEISAK   5.3-7.6
BLYXA   7.0
BLYXA ECHINOSPORA   7.0
BLYXA JAPONICA   7.0
BUTOMUS UMBELLATUS   6.0-8.9
CALDESIA RENIFORMIS   6.6-8.9
CALLA PALUSTRIS   5.2-9.8
CALTHA PALUSTRIS   6.0-9.4
CAREX   4.2-10.4
CAREX ACUTA   5.8-8.6
CAREX ALBOLUTESCENS   4.2-7.9
CAREX ANNECTENS   6.8-6.9
CAREX AQUATILIS   4.4-10.4

CAREX CANESCENS 7.4
CAREX COMOSA 6.3-9.8
CAREX DEMISSA 6.0-8.0
CAREX DIOCA 7.2
CAREX ECHINATA 6.0-7.3
CAREX ELATA 6.7-7.4
CAREX HUDSONII 4.9-8.3
CAREX LAEVIVAGINATA 7.1
CAREX LASIOCARPA 4.9-9.8
CAREX LEPTALEA 5.5-6.5
CAREX LUPILINA 6.1-7.5
CAREX LURIDA 4.9-8.4
CAREX NIGRA 6.0-8.7
CAREX PANICEA 6.0-8.0
CAREX PSEUDOCYPERUS 6.3-8.9
CAREX PULICARIS 6.0-7.3
CAREX ROSTRATA 4.4-10.4
CAREX SCOPARIA 6.4-7.1
CAREX STIPATA 6.0-6.8
CAREX VESICARIA 5.2-8.7
CAREX VULPINOIDES 6.6-8.8
CLADIUM JAMAICENSE 6.5-8.4
CYPERUS 4.0-8.6
CYPERUS DIFFORMIS 6.8-7.6
CYPERUS ERYTHROIDES 7.3
CYPERUS FILICINUS 6.7
CYPERUS ODORATUS 8.6
CYPERUS POLYSTACHYOS 4.0-7.6
CYPERUS PSEUDOVEGATUS 6.4-7.7
CYPERUS STRIGOSUS 6.3-7.0
CYPERUS TUBEROSUS 6.8-7.6
DULICHIUM ARUNDINACEUM 4.7-10.0
ECHINOCHLOA 4.7-9.3
ECHINOCHLOA CRUSGALLI 4.7-7.3
ECHINOCHLOA PYRAMIDALIS 6.8-7.6
ECHINOCHLOA WALTERI 6.1-9.3
ECHINODORUS CORDIFOLIUS 5.8-7.3
EGERIA DENSA 6.0-9.2
EICHHORNIA CRASSIPES 4.0-10.6
ELEOCHARIS 2.0-10.2
ELEOCHARIS ACICULARIS 2.9-9.8
ELEOCHARIS ALBIDA 6.8-8.6
ELEOCHARIS BALDWINII 5.6-6.8
ELEOCHARIS EQUISETOIDES 5.4
ELEOCHARIS FLAVESCENS 4.0-8.5
ELEOCHARIS MELANOCARPA 6.1
ELEOCHARIS MICROCARPA 4.6-7.4
ELEOCHARIS OBTUSA 3.1-8.7
ELEOCHARIS PALUSTRIS 4.1-10.2
ELEOCHARIS PARVULA 6.6-7.6
ELEOCHARIS QUADRANGULATA 6.5-7.3
ELEOCHARIS QUINQUEFOLIA 6.0-8.0
ELEOCHARIS ROBBINSII 4.6-6.5
ELEOCHARIS SELLOWIANA 2.0
ELEOCHARIS TENUIS 6.1-7.0
ELEOCHARIS TRICOSTATA 5.1-7.0
ELEOCHARIS TUBERCULOSA 4.9-7.6
ELEOCHARIS VIVIPARA 5.7-6.4
ELODEA 4.2-10.2
ELODEA CANADENSIS 4.2-10.2
ELODEA NUTTALLII 5.6-9.4

ERIOCAULON 4.2-9.3
ERIOCAULON COMPRESSUM 4.9-5.4
ERIOCAULON DECANGULARE 4.9-7.6
ERIOCAULON PELLUCIDUM 6.8
ERIOCAULON SEPTANGULARE 4.2-9.3
ERIOPHORUM 5.8-8.3
ERIOPHORUM ANGUSTIFOLIUM 5.8-8.3
ERIOPHORUM VIRGINICUM 6.4
FIMBRISTYLIS SPADICEA 7.6
FLOSCOPA AFRICANA 6.8-7.6
FUIRENA 5.2-10.0
FUIRENA PUMILA 10.0
FUIRENA SQUARROSA 5.2-7.6
FUIRENA UMBELLATA 6.8-7.6
GLYCERIA 4.2-8.9
GLYCERIA BOREALIS 6.4-8.8
GLYCERIA FLUITANS 4.2-8.3
GLYCERIA GRANDIS 7.2-8.8
GLYCERIA MAXIMA 6.2-8.9
GLYCERIA MELICARIA 6.5
GLYCERIA STRIATA 6.3-8.6
HETERANTHERA 5.0-9.8
HETERANTHERA DUBIA 5.0-9.8
HETERANTHERA RENIFORMIS 6.0-7.5
HYDRILLA VERTICILLATA 6.1-9.7
HYDROCHARIS 6.2-9.3
HYDROCHARIS DUBIA 6.7-9.3
HYDROCHARIS MORSUS-RANAE 6.2-8.9
HYDROCHLOA CAROLINIENSIS 6.1-6.8
IRIS 4.2-10.0
IRIS PRISMATICA 5.0-5.1
IRIS PSEUDACORUS 4.2-10.0
IRIS VIRGINICA 4.9-7.2
JUNCUS 3.1-10.5
JUNCUS ABORTIVUS 4.0-6.7
JUNCUS ACUMINATUS 4.2-8.4
JUNCUS ARTICULATUS 6.0-8.0
JUNCUS ALTICUS 7.8-10.5
JUNCUS BIFLORUS 6.0-7.2
JUNCUS BRACHYCARPUS 7.0
JUNCUS BREVICAUTATUS 6.6
JUNCUS BUFONIUS 5.3
JUNCUS BULBOSUS 3.5-7.3
JUNCUS CANADENSIS 4.7-7.6
JUNCUS CORIACEUS 5.0-8.7
JUNCUS DEBILIS 4.2-7.0
JUNCUS DIFFUSISSIMUS 6.0-7.7
JUNCUS EFFUSUS 3.1-8.4
JUNCUS ELLIOTII 5.6
JUNCUS FLUITANS 7.0-7.3
JUNCUS GYMNOCARPUS 5.5-7.0
JUNCUS MARGINATUS 6.0-8.7
JUNCUS MEGALOCEPHALUS 8.1
JUNCUS MILITARIS 4.3-7.6
JUNCUS PELOCARPUS 4.4-9.8
JUNCUS REPENS 4.7-8.2
JUNCUS ROEMERIANUS 6.6
JUNCUS SCIRPOIDES 5.0-8.1
JUNCUS SUBCAUDATUM 4.6-7.2
JUNCUS SUPINIFORMIS 3.7-9.0
JUNCUS SUPINUS 6.0-8.1

LACHNOCAULON	4.5-5.8
LACHNOCAULON ANCEPS	5.8
LACHNOCAULON MINUS	4.5
LEERSIA	5.0-9.0
LEERSIA HEXANDRA	5.0-5.7
LEERSIA ORYZOIDES	5.1-9.0
LEERSIA VIRGINICA	8.6
LEMNA	4.0-10.2
LEMNA CYCLOSTSA	5.2-7.7
LEMNA GIBBA	6.4-6.7
LEMNA MINIMA	7.2-7.5
LEMNA MINOR	4.0-10.2
LEMNA PAUCICOSTATA	4.1-9.6
LEMNA PERPUSILLA	4.5-8.2
LEMNA TRISULCA	4.6-10.0
LEMNA VALDIVIANA	5.2-7.4
LILAEA SCILLOIDES	6.5-7.5
LIMNOBIUM SPONGIA	3.5-6.9
LURONIUM NATANS	7.4
MARISCUS ALTERNIFLORUS	6.8-7.6
MAYACA	5.0-6.5
MAYACA AUBLETII	5.0-6.5
MAYACA FLUVIATILIS	5.6-5.7
MENYANTHES TRIFOLIATA	3.7-10.0
MONOCHORIA	6.5-6.6
MONOCHORIA KORSAKAWII	6.5
MONOCHORIA VAGINALIS	6.6
NAJAS	5.6-10.0
NAJAS FLEXILIS	5.6-10.0
NAJAS FOEVOLATA	6.9-7.8
NAJAS GRACILLIMA	6.2-8.3
NAJAS GRAMINEA	6.4-9.2
NAJAS GUADALUPENSIS	6.6-10.0
NAJAS JAPONICA	7.8
NAJAS MARINA	6.6-9.2
NAJAS MINOR	6.6-9.0
NAJAS OGURAENSIS	6.5-9.4
NAJAS TENUIFOLIA	7.6-8.2
ORONTIUM AQUATICUM	4.7-7.3
OTTELIA ALISMOIDES	6.9-7.8
PANICUM	4.0-7.6
PANICUM AGROSTOIDES	4.7-5.4
PANICUM HEMITOMON	5.0-6.2
PANICUM HIANS	4.0-7.6
PANICUM STIPITATUM	5.3
PANICUM VIRGATUM	6.5-7.6
PASPALUM	3.5-9.3
PASPALUM DISSECTUM	6.4
PASPALUM DISTICHUM	6.0-7.7
PASPALUM FLUITANS	3.5-5.9
PASPALUM VAGINATUM	9.3
PELTANDRA	5.1-9.5
PELTANDRA SAGITTAEFOLIA	5.1-6.9
PELTANDRA VIRGINICA	5.2-9.5
PHALARIS ARUNDINACEA	5.2-8.8
PHRAGMITES	4.2-9.8
PHRAGMITES COMMUNIS	4.2-9.8
PISTIA STRATIOTES	4.0-10.0
POA ANNUA	7.4
PONTEDERIA CORDATA	3.5-9.8

POTAMOGETON	3.1-10.4
POTAMOGETON ALPINUS	4.2-9.3
POTAMOGETON AMPLIFOLIUS	5.6-10.0
POTAMOGETON CONFERVOIDES	4.3-5.6
POTAMOGETON CRISPUS	5.6-9.7
POTAMOGETON CRISTATUS	6.4-7.8
POTAMOGETON DISTINCTUS	5.7-10.9
POTAMOGETON DIVERSIFOLIUS	5.0-9.8
POTAMOGETON EPIHYDRUS	3.1-9.2
POTAMOGETON FOLIOSUS	6.1-9.3
POTAMOGETON FREYERI	4.8-9.2
POTAMOGETON FRIESII	5.6-9.8
POTAMOGETON GRAMINEUS	3.7-10.0
POTAMOGETON ILLINOENSIS	5.6-9.4
POTAMOGETON MAACKIANUS	5.4-9.7
POTAMOGETON MALAIANUS	6.8-9.2
POTAMOGETON NATANS	3.7-10.0
POTAMOGETON NODOSUS	3.1-9.2
POTAMOGETON OAKESIANUS	4.3-6.0
POTAMOGETON OBTUSIFOLIUS	6.2-10.0
POTAMOGETON OCTANDRUS	5.7-9.6
POTAMOGETON OXYPHYLLUS	5.3-9.4
POTAMOGETON PECTINATUS	4.4-10.2
POTAMOGETON PERFOLIATUS	4.5-10.4
POTAMOGETON POLYGONIFOLIUS	6.0-7.3
POTAMOGETON PRAELONGUS	5.6-10.0
POTAMOGETON PULCHER	6.0-7.3
POTAMOGETON PUSILLUS	4.2-10.2
POTAMOGETON ROBBINSII	5.6-10.0
POTAMOGETON SPIRILLIS	6.0-8.3
POTAMOGETON STRICTIFOLIUS	7.3-9.0
POTAMOGETON ZOSTERIFORMIS	5.6-10.0
RHYNCHOSPORA	4.7-7.6
RHYNCHOSPORA CORNICULATA	5.1-7.4
RHYNCHOSPORA CORYMBOSA	6.8-7.6
RHYNCHOSPORA MACROSTACHYA	4.7-7.3
RHYNCHOSPORA TRACEYI	4.9-6.5
RUPPIA MARITIMA	6.4-10.5
SACCIOLEPIS STRIATA	4.1-6.5
SAGITTARIA	3.1-9.8
SAGITTARIA CALYCINA	8.5
SAGITTARIA CRISTATA	7.2-8.8
SAGITTARIA CUNEATA	6.5-9.0
SAGITTARIA ENGELMANNIANA	5.6-6.2
SAGITTARIA FALCATA	6.1-8.6
SAGITTARIA GRAMINEA	3.1-9.8
SAGITTARIA HETEROPHYLLA	6.4-9.3
SAGITTARIA LATIFOLIA	3.1-9.8
SAGITTARIA LONGIROSTRA	6.0-7.7
SAGITTARIA NATANS	5.7-8.7
SAGITTARIA RIGIDA	6.5-8.9
SAGITTARIA SAGITTIFOLIA	4.2-8.8
SAGITTARIA SUBULATA	6.7-7.2
SAGITTARIA TERES	4.5-5.9
SAGITTARIA TRIFOLIA	6.8-8.0
SCIRPUS	3.5-10.5
SCIRPUS AMERICANUS	3.5-10.3
SCIRPUS CALIFORNICUS	7.7-8.2
SCIRPUS CESPITOSIS	6.0-6.5
SCIRPUS CYPERINUS	4.8-8.4
SCIRPUS DIVARICATUS	8.2
SCIRPUS ETUBERCULATUS	4.8-7.4
SCIRPUS EXPANSUS	5.8-7.4

SCIRPUS FLUVIATILIS 7.9-9.1
SCIRPUS GEORGIANUS 6.3-8.8
SCIRPUS LACUSTRIS 4.2-10.5
SCIRPUS MARITIMUS 7.8-9.2
SCIRPUS POLYPHYLLUS 6.7-7.4
SCIRPUS PURSHIANUS 6.6-8.4
SCIRPUS ROBUSTUS 6.3-8.3
SCIRPUS RUBROTINCTUS 6.4-8.4
SCIRPUS SUBTERMINALIS 3.7-9.8
SCIRPUS SYLVATICUS 7.1
SCIRPUS TORREYI 6.7-9.8
SPARGANIUM 3.1-10.0
SPARGANIUM AFFINE 5.7-8.1
SPARGANIUM ANDROCLADUM 6.8
SPARGANIUM ANGUSTIFOLIUM 3.7-10.0
SPARGANIUM ERECTUM 4.2-8.4
SPARGANIUM EURYCARPUM 3.1-10.0
SPARGANIUM FLUCTUANS 5.6-9.8
SPARGANIUM FRIESII 4.9-8.4
SPARGANIUM MINIMUM 3.7-9.8
SPARTINA 4.9-7.7
SPARTINA ALTERNIFLORA 7.2-7.6
SPARTINA CYNOSUROIDES 4.9-7.7
SPARTINA PATENS 6.6-7.2
SPARTINA PECTINATUS 7.0
SPIRODELA 3.0-10.1
SPIRODELA OLIGORHIZA 3.0-10.0
SPIRODELA POLYRHIZA 5.5-10.1
STRATIOTES ALOIDES 6.1-8.9
SYNGONANTHUS FLAVIDULUS 4.7
TORULINIUM ODORATUM 6.8-7.6
TYPHA 3.1-10.2
TYPHA ANGUSTIFOLIA 6.0-8.9
TYPHA LATIFOLIA 3.5-10.2
VALLISNERIA 4.9-10.2
VALLISNERIA SPIRALIS 4.9-10.2
WOLFFIA 4.0-10.0
WOLFFIA ARRHIZA 4.0-10.0
WOLFFIA BOREALIS 6.0-8.5
WOLFFIA COLUMBIANA 5.8-8.5
WOLFFIA BRASILIENSIS 6.1-6.7
WOLFFIELLA 4.8-6.8
WOLFFIELLA FLORIDANA 4.8-6.8
XYRIS 4.7-8.2
XYRIS IRIDIFOLIA 5.0-8.2
XYRIS PLATYLEPIS 4.7-6.6
XYRIS SMALLIANA 5.0
ZANNICHELLIA PALUSTRIS 5.6-10.5
ZIZANIA AQUATICA 6.4-9.8
ZIZANIOPSIS MILIACEA 6.1-6.8

DICOTYLEDONS

AESCHYNOMENE 6.3-8.5
AESCHYNOMENE INDICA 8.5
AESCHYNOMENE VIRGINICA 6.3-7.8
AGERATUM 6.8-7.6
AGERATUM CONYZOIDES 6.8-7.6
ALTERNANTHERA 3.5-7.6
ALTERNANTHERA PHILOXEROIDES 3.5-6.8
ALTERNANTHERA SESSILIS 6.8-7.6
APIUM NODIFLORUM 7.0-8.4

BACOPA	5.4-7.7
BACOPA CAROLINIANA	5.9
BACOPA CYCLOPHYLLA	6.6
BACOPA MONNIERI	5.4-7.7
BATRACHIUM NIPPONICUS	7.1-8.3
BERULA ERECTA	7.0-8.4
BRASENIA SCHREBERI	3.5-10.0
CABOMBA CAROLINIANA	5.7-9.2
CALLITRICHE	4.2-9.6
CALLITRICHE ANCEPS	5.6-9.2
CALLITRICHE COPHOCARPA	5.8-7.3
CALLITRICHE HAMULATA	7.0
CALLITRICHE HERMAPHRODITICA	5.6-9.2
CALLITRICH HETEROPHYLLA	5.2-9.2
CALLITRICHE INTERMEDIA	5.8-6.5
CALLITRICHE OBTUSANGULA	7.0-8.4
CALLITRICHE POLYMORPHA	5.8-8.2
CALLITRICHE STAGNALIS	6.0-9.1
CALLITRICHE VERNA	4.2-9.6
CARDAMINE PRATENSE	7.3
CERATOPHYLLUM	3.5-10.0
CERATOPHYLLUM DEMERSUM	5.6-10.0
CERATOPHYLLUM ECHINATUM	3.5-8.0
CICUTA	5.6-10.0
CICUTA BULBIFERA	6.0-8.6
CICUTA DOUGLASII	5.6-10.0
CICUTA VIROSA	5.9-8.7
CYPHEA CARTHAGENSIS	5.2-7.7
DECODON VERTICILLATUS	4.7-9.8
ELATINE	4.7-9.8
ELATINE HYDROPIPER	5.3-8.7
ELATINE ORTHOSPERMA	6.6-7.3
ELATINE TRIANDRA	4.7-9.8
EPILOBIUM	7.0-8.4
EPILOBIUM HIRSUITUM	7.0-8.4
EPILOBIUM PALUSTRE	7.4
EUPATORIUM CANNABINUM	7.0-8.4
EURYALE FEROX	6.5-10.1
GALIUM PALUSTRE	7.4
GRATIOLA	5.1-9.2
GRATIOLA AUREA	7.5
GRATIOLA EBRACTEATA	6.5-7.8
GRATIOLA NEGLECTA	5.1-9.2
GRATIOLA VIRGINIANA	6.6
GRATIOLA VISCIDULA	6.0-7.3
HIPPURIS VULGARIS	4.2-10.0
HOTTONIA	6.3-8.9
HOTTONIA INFLATA	6.6-7.1
HOTTONIA PALUSTRIS	6.3-8.9
HYDROCOTYLE	3.5-9.3
HYDROCOTYLE AMERICANA	6.8
HYDROCOTYLE BONARIENSIS	3.5-7.6
HYDROCOTYLE RANUNCULOIDES	6.3
HYDROCOTYLE UMBELLATA	4.8-9.3
HYDROCOTYLE VULGARIS	7.3
HYDROLEA QUADRIVALVIS	5.8-8.3
JUSTICIA	5.1-7.5
JUSTICIA AMERICANA	6.2-7.5
JUSTICIA OVATA	5.1-7.4
LILAEOPSIS OCCIDENTALIS	6.5-7.8
LIMNOPHILA SESSILIFLORA	6.2-7.8

LIMOSELLA 5.6-9.2
LIMOSELLA AQUATICA 5.6-9.2
LIMOSELLA SUBULATA 6.9
LINDERNIA DUBIA 5.1-9.1
LITTORELLA 3.5-9.3
LITTORELLA AMERICANA 6.4-8.7
LITTORELLA UNIFLORA 3.5-9.3
LOBELIA 3.7-9.8
LOBELIA AMOENA 6.8
LOBELIA CARDINALIS 5.8-7.8
LOBELIA DORTMANNA 3.7-9.8
LOBELIA ELONGATA 6.2
LOBELIA NUTTALLII 7.0
LUDWIGIA 3.1-10.0
LUDWIGIA ALTERNIFOLIA 4.7-10.0
LUDWIGIA BREVIPES 5.2-6.2
LUDWIGIA DECURRENS 5.7-7.8
LUDWIGIA GLANDULOSA 6.0-7.3
LUDWIGIA LEPTOCARPA 5.3-7.6
LUDWIGIA LINEARIS 4.7-6.7
LUDWIGIA PALUSTRIS 3.1-9.3
LUDWIGIA PILOSA 4.8-7.7
LUDWIGIA SPHAEROCARPA 4.9-5.5
LUDWIGIA URUGUAYENSIS 6.1-7.3
LYCOPUS EUROPAEUS 5.9-7.4
LYSIMACHIA 4.2-9.8
LYSIMACHIA TERRESTRIS 5.9-7.4
LYSIMACHIA THYRSIFLORA 4.2-9.8
LYSIMACHIA VULGARIS 5.9-7.1
LYTHRUM 5.9-8.6
LYTHRUM LINEARE 8.3-8.6
LYTHRUM SALICARIA 5.9-8.4
MECARDONIA ACUMINATA 7.0
MEGALODENTA BECKII 5.6-9.8
MENTHA AQUATICA 6.2-84
MICRANTHEMUM UMBROSUM 5.3-8.3
MIMULUS 5.3-10.0
MIMULUS ALATUS 6.1-7.9
MIMULUS FLORIBUNDUS 5.6-9.2
MIMULUS GLABRATUS 6.7-8.9
MIMULUS GUTTATUS 5.6-10.0
MIMULUS RINGENS 5.3-8.2
MONTIA FONTANA 7.0-8.4
MYOSOTIS 5.6-10.2
MYOSOTIS LAXA 5.6-10.0
MYOSOTIS SCORPIOIDES 6.5-10.2
MYRIOPHYLLUM 2.9-10.5
MYRIOPHYLLUM ALTERNIFLORUM 4.5-8.8
MYRIOPHYLLUM AQUATICUM 5.2-7.7
MYRIOPHYLLUM EXALBESCENS 5.6-10.5
MYRIOPHYLLUM FARWELLII 6.1-7.6
MYRIOPHYLLUM HETEROPHYLLUM 3.1-9.0
MYRIOPHYLLUM HIPPUROIDES 6.4-7.8
MYRIOPHYLLUM HUMILE 5.8-7.0
MYRIOPHYLLUM LAXUM 4.9
MYRIOPHYLLUM PINNATUM 6.6-7.3
MYRIOPHYLLUM SPICATUM 2.9-10.2
MYRIOPHYLLUM TENELLUM 4.4-8.1
MYRIOPHYLLUM USSURIENSE 5.6-9.9
MYRIOPHYLLUM VERTICILLATUM 4.2-10.0
NELUMBO 3.5-9.8
NELUMBO NUCIFERA 6.2-9.8
NELUMBO PENTAPETALA 3.5-7.3

NUPHAR 3.7-10.0
NUPHAR LUTEA 4.2-9.8
NUPHAR MICROPHYLLUM 6.5-9.6
NUPHAR POLYSEPALUM 3.7-10.0
NUPHAR PUMILA 4.4-9.6
NUPHAR RUBRODISCUM 6.0-9.8
NUPHAR SUBINTERRIMUM 6.1-8.2
NUPHAR VARIEGATUM 4.0-9.8
NYMPHAEA 3.4-9.8
NYMPHAEA ALBA 3.4-9.3
NYMPHAEA CANDIDA 4.2-9.6
NYMPHAEA LOTUS 6.8-7.6
NYMPHAEA ODORATA 3.5-9.5
NYMPHAEA TETRAGONA 4.9-8.6
NYMPHAEA TUBEROSA 5.6-9.8
NYMPHOIDES 3.5-10.9
NYMPHOIDES AQUATICA 3.5-6.4
NYMPHOIDES CORDATUM 4.4-6.1
NYMPHOIDES INDICA 5.9-10.9
NYMPHOIDES PELTATA 5.9-8.8
OENANTHE 5.9-10.0
OENANTHE AQUATICA 6.2-8.9
OENANTHE SARMENTOSA 5.9-10.0
PENTODON PENTANDRUS 6.8-7.6
PEPLIS 5.8-7.3
PEPLIS DIANDRA 5.8-6.6
PEPLIS PORTULA 6.2-7.3
PODOSTEMUM CERATOPHYLLUM 6.8-7.8
POLYGONUM 3.5-10.2
POLYGONUM AMPHIBIUM 3.4-10.2
POLYGONUM ARIFOLIUM 6.0-7.3
POLYGONUM DENSIFLORUM 6.4
POLYGONUM HIRSUTUM 7.4
POLYGONUM HYDROPIPER 5.9-8.7
POLYGONUM HYDROPIPEROIDES 3.5-10.0
POLYGONUM LAPPATHIFOLIUM 8.7
POLYGONUM PUNCTATUM 3.5-8.7
POLYGONUM SAGITTATUM 5.8-8.4
POLYGONUM SALICIFOLIUM 6.8-7.6
POTENTILLA PALUSTRIS 4.3-10.4
PROSERPINACA 4.3-7.3
PROSERPINACA INTERMEDIA 4.9-5.9
PROSERPINACA PALUSTRIS 4.3-7.3
PROSERPINACA PECTINATA 5.0-6.1
RANUNCULUS 3.7-10.4
RANUNCULUS AQUATILIS 5.6-10.0
RANUNCULUS CYMBALARIA 7.6-10.3
RANUNCULUS FLABELLARIS 5.6-9.2
RANUNCULUS FLAMMULA 3.7-10.2
RANUNCULUS HYPERBOREUS 5.6-9.2
RANUNCULUS LINGUA 6.2-8.9
RANUNCULUS PELTATUS 5.3-10.4
RANUNCULUS PENICILLATUS 6.5-10.3
RANUNCULUS PSEUDOFLUITANS 7.2-8.9
RANUNCULUS PUSILLUS 6.6-7.1
RANUNCULUS REPENS 7.0-9.3
RANUNCULUS SCELERATUS 6.7-10.2
RANUNCULUS SUBCORDATUS 6.0-6.8
RORIPPA 5.6-9.8
RORIPPA AMPHIBIA 6.2-7.3
RORIPPA NASTURTIUM-AQUATICUM 5.6-9.8
RORIPPA PALUSTRIS 7.4

ROTALA RAMOSIOR	6.2-7.6
RUMEX	5.9-9.8
RUMEX AQUATICUS	5.9-9.8
RUMEX HYDROLAPATHUM	6.2-8.9
RUMEX VERTICILLATUS	6.1-7.2
SAMOLUS PARVIFLORUS	6.1-8.7
SCROPHULARIA AURICULATA	7.0-8.4
SIUM	5.6-10.0
SIUM LATIFOLIUM	6.3-8.9
SIUM SAUVE	5.6-10.0
SOLANUM DULCAMARA	7.0-8.9
SUBULARIA AQUATICA	5.3-9.2
TILLAEA AQUATICA	5.6-9.2
TRAPA	5.9-10.5
TRAPA INCISA	7.0-8.1
TRAPA JAPONICA	5.9-10.5
TRAPA NATANS	6.7-10.0
UTRICULARIA	3.5-10.2
UTRICULARIA AUREA	5.7-9.3
UTRICULARIA AUSTRALIS	5.9-8.7
UTRICULARIA CORNUTA	4.6-7.6
UTRICULARIA EXOLETA	7.2-7.4
UTRICULARIA GEMINISCAPA	3.5-8.6
UTRICULARIA GIBBA	3.5-8.6
UTRICULARIA INFLATA	6.1-7.6
UTRICULARIA INTERMEDIA	3.7-8.9
UTRICULARIA JAPONICA	4.9-8.3
UTRICULARIA MINOR	4.2-9.0
UTRICULARIA OLIVACEA	4.9
UTRICULARIA PURPUREA	4.3-7.6
UTRICULARIA RADIATA	5.6-7.3
UTRICULARIA RESUPINATA	4.4-7.6
UTRICULARIA SUBULATA	4.6
UTRICULARIA VULGARIS	3.7-10.2
VERONICA	5.6-10.0
VERONICA AMERICANA	5.6-10.0
VERONICA ANAGALLIS-AQUATICA	6.0-7.9
VERONICA BECCABUNGA	7.0-8.4
VERONICA CATENATA	7.0-8.4
VERONICA SCUTELLATA	5.6-9.3

DOCUMENTED ALKALINITY RANGES FOR AQUATIC PLANT GENERA AND SPECIES(REF)

1.AQUATIC MACROALGAE

CHARA 78-84(52)
CHARA ASPERA 37-135(73)
CHARA DELICATULA 61-135(73)
CHARA GLOBULARIS 59(73)
CHARA PAPILLOSUM 135(73)
NITELLA 2-57(73)
NITELLA OPACA 37-44(73)
NITELLA TRANSLUCENS 2-57(73)

2. AQUATIC LIVERWORTS

RICCIA FLUITANS 20-40(59)
RICCIOCARPUS NATANS 27-74(59)

3. AQUATIC MOSSES

DREPANOCLADUS 0-57(73)
DREPANOCLADUS EXANNULATUS 0(73)
DREPANOCLADUS REVOLVENS 57(73)
FONTINALIS ANTIPYRETICA 115-296(56),2-76(73)
SPHAGNUM 0-90(73)
SPHAGNUM CUSPIDATUM 0(73)
SPHAGNUM PALUSTRE 0(73)
SPHAGNUM SQUARROSUM 90(73)
SPHAGNUM SUBSECUNDUM 0(73)

4. AQUATIC QUILLWORTS

ISOETES 16-32(59),8-45(67),2(73)
ISOETES BRAUNII 8-45(67)
ISOETES JAPONICA 16-31(59)

5. AQUATIC HORSETAILS

EQUISETUM FLUVIATILE 7-298(67),90(73)

6. AQUATIC FERNS

SALVINIA NATANS 20-121(59)

7. AQUATIC FLOWERING PLANTS

MONOCOTYLEDONS

ACORUS CALAMUS 20-203(67)
AGROSTIS 0-70(73)
AGROSTIS CANINA 90(73)
AGROSTIS TENUIS 0(73)
ALISMA 14-95(59),32-298(67),11-290(72)
ALISMA CANALICULATAUM 14-95(59)
ALISMA GRAMINEUM 48(72)
ALISMA PLANTAGO-AQUATICA 32-298(67),11-290(72)
BLYXA 7(59)
BLYXA ECHINOSPORA 7(59)
BLYXA JAPONICA 7(59)
BUTOMUS UMBELLATUS 55-153(72)
CALDESIA RENIFORMIS 11-78(59)
CALLA PALUSTRIS 0-50(68)

CAREX 0-90(73)
CAREX DEMISSA 57(73)
CAREX ECHINATA 0(73)
CAREX NIGRA 0-90(73)
CAREX PANICEA 57(73)
CAREX ROSTRATA 57-90(73)
CAREX VESICARIA 90(73)
EGERIA DENSA 22-103(50),9(59)
EICHHORNIA CRASSIPES 17-126(59)
ELEOCHARIS 0-376(67),51(73)
ELEOCHARIS ACICULARIS 19-376(67)
ELEOCHARIS PALUSTRIS 0-220(67)
ELEOCHARIS QUINQUEFOLIA 57(73)
ELODEA 5-103(50),38-68(55),115-295(56),9-98(59),22-298(67),22-228(68)
5-153(72),12-14(73)
ELODEA CANADENSIS 38-68(55),115-295(56),35-298(67),22-228(68),
10-153(72),12-14(73)
ELODEA NUTTALLII 5-80(50),39-68(55),13-98(59),22-203(67),5-109(72)
ERIOCAULON SEPTANGULARE 10-44(67),2-30(72)
ERIOPHORUM ANGUSTIFOLIUM 0(73)
GLYCERIA 8-188(67)
GLYCERIA BOREALIS 8-188(67)
GLYCERIA GRANDIS 8-245(67)
HETERANTHERA DUBIA 38-78(55),22-245(67),26-112(68),19-153(72)
HYDRILLA VERTICILLATA 6-45(50),8-80(59)
HYDROCHARIS DUBIA 29-153(50),49-79(59)
JUNCUS 0-57(73)
JUNCUS ARTICULATUS 57(73)
JUNCUS BULBOSUS 0(73)
JUNCUS FLUITANS 12-37(73)
LEERSIA ORYZOIDES 30-277(67)
LEMNA 151-194(42),78-84(52),14-135(59),141-298(67),2-153(72)
LEMNA MINIMA 49-74(59)
LEMNA MINOR 151-194(42),27-135(59),41-263(67),2-153(72)
LEMNA PAUCICOSTATA 14-77(59)
LEMNA PERPUSILLA 78-84(52)
LEMNA TRISULCA 41-298(67),26-153(72)
LEMNA VALDIVIANA 69-126(59)
MENYANTHES TRIFOLIATA 90(73)
MONOCHORIA 6-7(59)
MONOCHORIA KORSAKOWII 6(59)
MONOCHORIA VAGINALIS 7(59)
NAJAS 10-80(50),78-84(52),38-68(55),3-121(59),19-376(67)
NAJAS FLEXILIS 38-68(55),19-307(67),16-222(68)
NAJAS FOEVOLATA 27-95(59)
NAJAS GRAMINEA 11-95(59)
NAJAS GUADALUPENSIS 39-68(55),75-160(67)
NAJAS JAPONICA 32(59)
NAJAS MARINA 10-60(50),3-51(59),147-376(67)
NAJAS MINOR 10-80(50),13-75(59)
NAJAS OGURAENSIS 12-74(59)
NAJAS TENUIFOLIA 78-84(52)
OTTELIA ALISMOIDES 17-121(59)
PELTANDRA VIRGINICA 1-89(72)
PHALARIS ARUNDINACEA 22-134(67)
PHRAGMITES COMMUNIS 0-298(67)
PONTEDERIA CORDATA 19-93(67),2-112(72)

POTAMOGETON	1-283(2),2-153(51),38-88(55),7-95(59),12-376(67), 0-448(68),0-135(73)
POTAMOGETON ALPINUS	5-140(2),18-41(51),12-114(67),12-37(73)
POTAMOGETON AMPLIFOLIUS	4-151(2),38-68(55),12-209(67),10-119(68)
POTAMOGETON BICUPULATUS	2-26(2)
POTAMOGETON CONFERVOIDES	1-9(2)
POTAMOGETON CRISPUS	15-208(2),13-153(51),38-68(55),42(59), 113-263(67),2-14(73)
POTAMOGETON CRISTATUS	9(51),16-95(59)
POTAMOGETON DISTINCTUS	4-84(51),7-95(59)
POTAMOGETON DIVERSIFOLIUS	2(2),38-56(55)
POTAMOGETON EPIHYDRUS	2-162(2),38-56(55),10-114(67),10-72(68)
POTAMOGETON FILIFORMIS	29-107(2)
POTAMOGETON FOLIOSUS	17-168(2),38-68(55),37-229(67)
POTAMOGETON FRIESII	43-151(2),72-376(67)
POTAMOGETON FREYERI	2-72(51),12-35(59)
POTAMOGETON GRAMINEUS	3-51(2),13-97(51),38-68(55),30-170(67), 22-313(68),57-135(73)
POTAMOGETON HILLII	135-162(2)
POTAMOGETON ILLINOENSIS	24-151(2),38-68(55),12-308(67)
POTAMOGETON LATERALIS	17(2)
POTAMOGETON MAACKIANUS	9-62(51)
POTAMOGETON MALAIANUS	20-104(51)
POTAMOGETON NATANS	3-162(2),5-112(51),38-68(55),19-307(67),4-228(68) 4-228(68),12-135(73)
POTAMOGETON NODOSUS	6-283(2),41-312(67)
POTAMOGETON OAKESIANUS	2-24(2)
POTAMOGETON OBTUSIFOLIUS	16-128(2),53(51),30-70(67),20-70(68), 2-14(73)
POTAMOGETON OCTANDRUS	3-81(51),9-64(59)
POTAMOGETON OXYPHYLLUS	5-81(51),18(59)
POTAMOGETON PECTINATUS	29-283(2),31-116(51),38-56(55),32-376(67), 61-135(73)
POTAMOGETON PERFOLIATUS	16-168(2),9-60(51),36-68(55),32-376(67), 15-448(68),2-78(73)
POTAMOGETON POLYGONIFOLIUS	0(73)
POTAMOGETON PRAELONGUS	10-151(2),13-31(51),38-68(55),12-308(67), 30-254(68),20-135(73)
POTAMOGETON PULCHER	4-46(2)
POTAMOGETON PUSILLUS	3-206(2),10-96(51),38-68(55),31-188(67), 2-57(73)
POTAMOGETON ROBBINSII	4-122(2),38-88(55),32-144(67)
POTAMOGETON SPIRILLUS	3-70(2),19-46(67),10-85(68)
POTAMOGETON STRICTIFOLIUS	67-110(2),32-263(67)
POTAMOGETON VASEYI	8-55(2),38-56(55)
POTAMOGETON ZOSTERIFORMIS	5-151(2),38-68(55),18-245(67),25-170(68)
RUPPIA MARITIMA	147-376(67),86-800(68)
SAGITTARIA	31-61(59),0-376(67),22-112(68).1-290(72)
SAGITTARIA CRISTATA	19-183(67)
SAGITTARIA CUNEATA	20-376(67),5-127(72)
SAGITTARIA GRAMINEA	3-112(72)
SAGITTARIA LATIFOLIA	0-298(67),1-290(72)
SAGITTARIA RIGIDA	32-298(67),22-112(68),10-58(72)
SAGITTARIA SUBULATA	15-35(72)
SAGITTARIA TERES	4-7(72)
SAGITTARIA TRIFOLIA	31-61(59)
SCIRPUS	8-276(67)
SCIRPUS AMERICANUS	88-277(67)7
SCIRPUS FLUVIATILIS	30-220(67)
SCIRPUS LACUSTRIS	17-220(67)
SCIRPUS MARITIMUS	147-198(67)
SCIRPUS SUBTERMINALIS	8-43(67)

SPARGANIUM 115-296(56),16-376(67),10-336(68),0-170(72),44-57(73)
SPARGANIUM ANDROCLADUM 15(72)
SPARGANIUM ANGUSTIFOLIUM 16-144(67),3-138(72)
SPARGANIUM ERECTUM 115-296(56)
SPARGANIUM EURYCARPUM 35-376(67),0-124(72)
SPARGANIUM FLUCTUANS 20-45(67),13-50(72)
SPARGANIUM MINIMUM 3-70(72),44-57(73)
SPIRODELA 18-103(50),116-126(59),49-298(67),4-176(68)
SPIRODELA OLIGORHIZA 18-77(59)
SPIRODELA POLYRHIZA 18-103(50),16-126(59),49-298(67),4-176(68)
TYPHA 10-376(67),1-170(72)
TYPHA ANGUSTIFOLIA 7-140(72)
TYPHA LATIFOLIA 10-376(67),1-170(72)
VALLISNERIA SPIRALIS 9-60(50),38-68(55),14-54(59),19-277(67),
10-200(68),3-116(72)
WOLFFIA 74-75(59),85-220(67),12-107(72)
WOLFFIA ARRHIZA 74-75(59)
WOLFFIA BOREALIS 12-107(72)
WOLFFIA COLUMBIANA 85-220(67),12-107(72)
ZANNICHELLIA PALUSTRIS 75-338(67)
ZIZANIA AQUATICA 8-298(67),0-222(68)

DICOTYLEDONS

APIUM NODIFLORUM 115-296(56)
BATRACHIUM NIPPONICUS 9-40(59)
BERULA ERECTA 115-296(56)
BRASENIA SCHREBERI 2-47(50),8-64(59),32-144(67),8-80(68),2-112(72)
CABOMBA CAROLINIANA 16-58(59),3-35(72)
CALLITRICHE 115-296(56),37-44(73)
CALLITRICHE HERMAPHRODITICA 37-44(73)
CALLITRICHE OBTUSANGULA 115-296(56)
CALLITRICHE STAGNALIS 115-296(56),44(73)
CERATOPHYLLUM 9-451(50),38-68(55),14-80(59),23-376(67),5-151(72)
CERATOPHYLLUM DEMERSUM 9-451(50),38-68(55),14-80(59),23-376(67),
5-151(72)
CICUTA VIROSA 90(73)
EPILOBIUM HIRSUTUM 115-296(56)
EUPATORIUM CANNABINUM 115-296(56)
EURYALE FEROX 12-80(59)
HIPPURIS VULGARIS 30-297(67),12-50(72)
LIMNOPHILA SESSILIFLORA 14-121(59)
LITTORELLA UNIFLORA 0(3),12-135(73)
LOBELIA DORTMANNA 0-8(3),12-42(67),12-37(73)
LYTHRUM SALICARIA 115-296(56)
MEGALODENTA BECKII 38-68(55),32-190(67),25-134(68)
MENTHA AQUATICA 115-296(56)
MYOSOTIS SCORPIOIDES 115-296(56)
MYRIOPHYLLUM 5-145(50),38-68(55),8-76(59),22-376(67),2-124(72),
2-135(73)
MYRIOPHYLLUM ALTERNIFLORUM 5-78(72),2-37(73)
MYRIOPHYLLUM EXALBESCENS 38-68(55),22-376(62),13-123(72)
MYRIOPHYLLUM FARWELLII 3-10(72)
MYRIOPHYLLUM HETEROPHYLLUM 3-33(72)
MYRIOPHYLLUM HUMILE 2-13(72)
MYRIOPHYLLUM SPICATUM 13-145(50),12-103(72),78-135(73)
MYRIOPHYLLUM TENELLUM 38-68(55),3-20(72)
MYRIOPHYLLUM USSURIENSE 6-34(50),8-32(59)
MYRIOPHYLLUM VERTICILLATUM 5-97(50),8-76(59),5-39(72)
NELUMBO 20,59,61,65
NELUMBO NUCIFERA 15-135(59)

NUPHAR   2-68(50),10-58(59),0-220(67),6-298(68),2-133(72)
NUPHAR JAPONICUM   6-68(50)
NUPHAR MICROPHYLLUM   7-41(67)
NUPHAR PUMILA   2-34(50),3-104(72)
NUPHAR RUBRODISCUM   0-32(67)
NUPHAR SUBINTEGERRIMUM   10-58(59)
NUPHAR VARIEGATUM   7-220(67),6-298(68),2-133(72)
NYMPHAEA   1-52(50),7-96(59),19-297(67),4-100(68)
NYMPHAEA ODORATA   37-163(67),4-100(68)
NYMPHAEA TETRAGONA   1-52(50),7-95(59),12-88(68)
NYMPHAEA TUBEROSA   19-297(67)
NYMPHOIDES   7-63(50),10-92(59)
NYMPHOIDES INDICA   7-63(50),10-67(59)
NYMPHOIDES PELTATA   10-92(59)
POLYGONUM   30-260(67),12-328(68)
POLYGONUM AMPHIBIUM   30-260(67),12-328(68)
POTENTILLA PALUSTRIS   90(73)
PROSERPINACA PALUSTRIS   2-100(72)
RANUNCULUS   39-68(55),115-296(56),125-298(67),0-37(73)
RANUNCULUS AQUATILIS   39-68(55),113-298(67),13-37(73)
RANUNCULUS FLAMMULA   0(73)
RANUNCULUS PELTATUS   115-295(56)
RANUNCULUS PENICILLATUS   115-296(56)
RORIPPA NASTURTIUM-AQUATICUM   115-296(56)
SCROPHULARIA AURICULATA   115-296(56)
TRAPA   7-60(50),7-118(59),12-128(72)
TRAPA INCISA   13-58(59)
TRAPA JAPONICA   7-28(50),7-118(59)
TRAPA NATANS   12-60(50),12-128(72)
UTRICULARIA   3-116(50),7-74(59),8-298(67),1-109(72),2-57(73)
UTRICULARIA AUREA   7-43(59)
UTRICULARIA AUSTRALIS   7-64(59)
UTRICULARIA CORNUTA   1-7(72)
UTRICULARIA EXOLETA   14-74(59)
UTRICULARIA GEMINISCAPA   5-70(72)
UTRICULARIA GIBBA   3-70(72)
UTRICULARIA INTERMEDIA   8-245(67),3-53(72)
UTRICULARIA JAPONICA   3-116(50)
UTRICULARIA MINOR   10(59),3-34(72)
UTRICULARIA PURPUREA   2-33(72)
UTRICULARIA RADIATA   1-33(72)
UTRICULARIA VULGARIS   16-298(67),2-109(72),2-57(73)
VERONICA   115-296(56)
VERONICA BECCABUNGA   115-296(56)
VERONICA CATENATA   115-296(56)

ALKALINITY RANGES FOR AQUATIC PLANT GENERA AND SPECIES

1.AQUATIC MACROALGAE

CHARA	37-135
CHARA ASPERA	37-135
CHARA DELICATULA	61-135
CHARA GLOBULARIS	59
CHARA PAPILLOSUM	135
NITELLA	2-57
NITELLA OPACA	37-144
NITELLA TRANSLUCENS	2-57

2. AQUATIC LIVERWORTS

RICCIA FLUITANS	20-40
RICCIOCARPUS NATANS	27-74

3. AQUATIC MOSSES

DREPANOCLADUS	0-57
DREPANOCLADUS EXANNULATUS	0
DREPANOCLADUS REVOLVENS	57
FONTINALIS ANTIPYRETICA	2-296
SPHAGNUM	0-90
SPHAGNUM CUSPIDATUM	0
SPHAGNUM PALUSTRE	0
SPHAGNUM SQUARROSUM	90
SPHAGNUM SUBSECUNDUM	0

4. AQUATIC QUILLWORTS

ISOETES	2-45
ISOETES BRAUNII	8-45
ISOETES JAPONICA	16-32
ISOETES LACUSTRIS	2

5. AQUATIC HORSETAILS

EQUISETUM FLUVIATILE	7-298

6. AQUATIC FERNS

SALVINIA NATANS	20-121

7. AQUATIC FLOWERING PLANTS

MONOCOTYLEDONS

ACORUS CALAMUS	20-203
AGROSTIS	0-90
AGROSTIS CANINA	90
AGROSTIS TENUIS	0
ALISMA	11-298
ALISMA CANALICULATAUM	14-95
ALISMA GRAMINEA	48
ALISMA PLANTAGO-AQUATICA	11-298
BLYXA	7
BLYXA ECHINOSPORA	7
BLYXA JAPONICA	7
BUTOMUS UMBELLATUS	55-153

CALDESIA RENIFORMIS	11-78
CALLA PALUSTRIS	0-50
CAREX	0-90
CAREX DEMISSA	57
CAREX ECHINATA	0
CAREX NIGRA	0-90
CAREX PANICEA	57
CAREX ROSTRATA	57-90
CAREX VESICARIA	90
EGERIA DENSA	9-103
EICHHORNIA CRASSIPES	17-126
ELEOCHARIS	0-376
ELEOCHARIS ACICULARIS	19-376
ELEOCHARIS PALUSTRIS	0-220
ELEOCHARIS QUINQUEFOLIA	57
ELODEA	5-298
ELODEA CANADENSIS	10-298
ELODEA NUTTALLII	5-203
ERIOCAULON SEPTANGULARE	2-44
ERIOPHORUM ANGUSTIFOLIUM	0
GLYCERIA	8-245
GLYCERIA BOREALIS	8-188
GLYCERIA GRANDIS	8-245
HETERANTHERA DUBIA	19-245
HYDRILLA VERTICILLATA	6-80
HYDROCHARIS DUBIA	29-153
JUNCUS	0-57
JUNCUS ARTICULATUS	57
JUNCUS BULBOSUS	0
JUNCUS FLUITANS	12-37
LEERSIA ORYZOIDES	30-277
LEMNA	2-298
LEMNA MINIMA	49-74
LEMNA MINOR	2-263
LEMNA PAUCICOSTATA	14-71
LEMNA PERPUSILLA	78-84
LEMNA TRISULCA	41-153
LEMNA VALDIVIANA	69-126
MENYANTHES TRIFOLIATA	90
MONOCHORIA	6-7
MONOCHORIA KORSAKOWII	6
MONOCHORIA VAGINALIS	7
NAJAS	3-376
NAJAS FLEXILIS	16-307
NAJAS FOEVOLATA	27-95
NAJAS GRAMINEA	11-95
NAJAS GUADALUPENSIS	39-160
NAJAS JAPONICA	31
NAJAS MARINA	3-376
NAJAS MINOR	10-80
NAJAS OGURAENSIS	12-74
NAJAS TENUIFOLIA	78-84
OTTELIA ALISMOIDES	17-121
PELTANDRA VIRGINICA	1-89
PHALARIS ARUNDINACEA	22-134
PHRAGMITES COMMUNIS	0-298
PONTEDERIA CORDATA	2-112

POTAMOGETON 0-448
POTAMOGETON ALPINUS 5-140
POTAMOGETON AMPLIFOLIUS 4-209
POTAMOGETON BICUPULATUS 2-26
POTAMOGETON CONFERVOIDES 1-9
POTAMOGETON CRISPUS 2-263
POTAMOGETON CRISTATUS 8-95
POTAMOGETON DISTINCTUS 4-95
POTAMOGETON DIVERSIFOLIUS 2-56
POTAMOGETON EPIHYDRUS 0-162
POTAMOGETON FOLIOSUS 17-229
POTAMOGETON FRIESII 43-376
POTAMOGETON FREYERI 2-72
POTAMOGETON GRAMINEUS 3-313
POTAMOGETON HILLII 135-162
POTAMOGETON ILLINOENSIS 12-308
POTAMOGETON LATERALIS 16
POTAMOGETON MAACKIANUS 9-62
POTAMOGETON MALAIANUS 20-104
POTAMOGETON NATANS 3-307
POTAMOGETON NODOSUS 6-312
POTAMOGETON OAKESIANUS 2-24
POTAMOGETON OBTUSIFOLIUS 2-128
POTAMOGETON OCTANDRUS 3-81
POTAMOGETON OXYPHYLLUS 6-81
POTAMOGETON PECTINATUS 29-376
POTAMOGETON PERFOLIATUS 2-448
POTAMOGETON POLYGONIFOLIUS 0
POTAMOGETON PRAELONGUS 10-308
POTAMOGETON PULCHER 4-46
POTAMOGETON PUSILLUS 2-206
POTAMOGETON ROBBINSII 4-144
POTAMOGETON SPIRILLUS 3-85
POTAMOGETON STRICTIFOLIUS 32-263
POTAMOGETON VASEYI 8-56
POTAMOGETON ZOSTERIFORMIS 5-245
RUPPIA MARITIMA 86-800
SAGITTARIA 0-376
SAGITTARIA CRISTATA 19-183
SAGITTARIA CUNEATA 5-376
SAGITTARIA GRAMINEA 3-112
SAGITTARIA LATIFOLIA 0-298
SAGITTARIA RIGIDA 10-298
SAGITTARIA SUBULATA 15-35
SAGITTARIA TERES 4-7
SAGITTARIA TRIFOLIA 31-61
SCIRPUS 8-277
SCIRPUS AMERICANUS 88-277
SCIRPUS FLUVIATILIS 30-220
SCIRPUS LACUSTRIS 17-220
SCIRPUS MARITIMUS 147-198
SCIRPUS SUBTERMINALIS 8-43
SPARGANIUM 0-376
SPARGANIUM ANDROCLADUM 15
SPARGANIUM ANGUSTIFOLIUM 2-144
SPARGANIUM ERECTUM 115-296
SPARGANIUM EURYCARPUM 0-276
SPARGANIUM FLUCTUANS 3-50
SPARGANIUM MINIMUM 3-70
SPIRODELA 4-298
SPIRODELA OLIGORHIZA 18-77
SPIRODELA POLYRHIZA 4-298

TYPHA 1-376
TYPHA ANGUSTIFOLIA 7-138
TYPHA LATIFOLIA 1-376
VALLISNERIA 3-277
VALLISNERIA SPIRALIS 3-277
WOLFFIA 12-220
WOLFFIA ARRHIZA 74-75
WOLFFIA BOREALIS 12-107
WOLFFIA COLUMBIANA 12-220
ZANNICHELLIA PALUSTRIS 75-338
ZIZANIA AQUATICA 0-298

DICOTYLEDONS

APIUM NODIFLORUM 115-296
BATRACHIUM NIPPONICUS 9-40
BERULA ERECTA 115-296
BRASENIA SCHREBERI 2-144
CABOMBA CAROLINIANA 3-58
CALLITRICHE 115-296
CALLITRICHE HERMAPHRODITICA 37-44
CALLITRICHE OBTUSANGULA 115-296
CALLITRICHE STAGNALIS 115-296
CERATOPHYLLUM 5-451
CERATOPHYLLUM DEMERSUM 5-451
CERATOPHYLLUM ECHINATUM 6-120
CICUTA VIROSA 90
EPILOBIUM HIRSUTUM 115-296
EUPATORIUM CANNABINUM 115-296
EURYALE FEROX 12-80
HIPPURIS VULGARIS 12-297
LIMNOPHILA SESSILIFLORA 14-121
LITTORELLA UNIFLORA 0-135
LOBELIA DORTMANNA 0-42
LYTHRUM SALICARIA 115-296
MEGALODONTA BECKII 25-190
MENTHA AQUATICA 115-296
MYOSOTIS SCORPIOIDES 115-296
MYRIOPHYLLUM 2-376
MYRIOPHYLLUM ALTERNIFLORUM 2-78
MYRIOPHYLLUM EXALBESCENS 13-376
MYRIOPHYLLUM FARWELLII 3-10
MYRIOPHYLLUM HETEROPHYLLUM 3-33
MYRIOPHYLLUM HUMILE 2-13
MYRIOPHYLLUM SPICATUM 12-145
MYRIOPHYLLUM TENELLUM 3-68
MYRIOPHYLLUM USSURIENSE 6-34
MYRIOPHYLLUM VERTICILLATUM 5-97
NELUMBO NUCIFERA 15-135
NUPHAR 0-298
NUPHAR JAPONICUM 6-68
NUPHAR MICROPHYLLUM 7-41
NUPHAR PUMILA 2-104
NUPHAR RUBRODISCUM 0-32
NUPHAR SUBINTEGERRIMUM 10-58
NUPHAR VARIEGATUM 2-298
NYMPHAEA 1-297
NYMPHAEA ODORATA 2-163
NYMPHAEA TETRAGONA 1-95
NYMPHAEA TUBEROSA 10-297
NYMPHOIDES 7-92
NYMPHOIDES INDICA 7-67
NYMPHOIDES PELTATA 10-92

POLYGONUM	12-328
POLYGONUM AMPHIBIUM	12-328
POTENTILLA PALUSTRIS	90
PROSERPINACA PALUSTRIS	2-100
RANUNCULUS	0-298
RANUNCULUS AQUATILIS	13-298
RANUNCULUS FLAMMULA	0
RANUNCULUS PELTATUS	115-296
RANUNCULUS PENICILLATUS	115-296
RORIPPA NASTURTIUM-AQUATICUM	115-296
SCROPHULARIA AURICULATA	115-296
TRAPA	7-128
TRAPA INCISA	13-58
TRAPA JAPONICA	7-118
TRAPA NATANS	12-128
UTRICULARIA	1-298
UTRICULARIA AUREA	7-43
UTRICULARIA AUSTRALIS	7-64
UTRICULARIA CORNUTA	1-7
UTRICULARIA EXOLETA	14-74
UTRICULARIA GEMINISCAPA	5-70
UTRICULARIA GIBBA	3-70
UTRICULARIA INTERMEDIA	3-245
UTRICULARIA JAPONICA	3-116
UTRICULARIA MINOR	3-34
UTRICULARIA PURPUREA	2-33
UTRICULARIA RADIATA	1-33
UTRICULARIA VULGARIS	2-298
VERONICA	115-296
VERONICA BECCABUNGA	115-296
VERONICA CATENATA	115-296

Fig. I. The Form of Inorganic Carbon as a Function of pH.